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ABSTRACT

The keynote address, given by Michael Allen, characterized the association as a group of devoted humanitarians who are committed to finding realistic educational and training alternatives. He discussed the potential role of computer-based education specialists in meeting general and specific instructional needs. Included in the proceedings are 59 papers arranged under the following section headings: general session, project reports, educators for the deaf, elementary/secondary/junior college, health education network users, and health sciences. See related documents for individual papers. (VT)

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New Directions In Educational Computing

ADCIS

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

IR006231

March 1-4, 1978

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THE ART OF SCIENCE: Professionalism in CBI
(or Standing on Each Other's Feet)

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I have an incredible sense of respect for this group and the 20th Century phenomenon of ADCIS. Rarely has any group faced the level of challenge the members of this organization eagerly welcome and tackle daily. Moreover, the challenge is met by each of us, individually and sometimes collectively, with a conviction and a deep inner knowledge that what we propose and strive for is right. The consequences of reaching our goals will be so far reaching that they cannot be described by anything less than a social and technological revolution.

ADCIS is not an assembly of computer freaks nor is it an assembly of teachers, professors, deans, superintendents, training directors, general managers, doctors, or musicians; but certainly there are many of these in our ranks. ADCIS is not a homogenious group in any sense, except one: we are a group of devoted humanitarians who are, on one hand, enraged about current educational practices, and on the other hand, committed to finding realistic educational and training alternatives--alternative approaches which recognize individual differences: needs, abilities, aspirations, hopes, motivations, etc. -- alternative approaches which do not confuse organizational discipline with instruction -- alternative approaches which are not so concerned with selection of a top notch, blue ribbon student population as they are with finding and providing the appropriate instructional experience for everyone who wants to learn.

Each of us has ideas, important ideas, on how to provide appropriate instructional experiences and on the relative importance of various technologies in providing them. Because of the history and name of this organization, it is also safe to say that many of us feel the computer is important in reaching our goals. We do, indeed, find amoung us very many different ideas on what role the computer can and should play in educational efforts. And it is the volume and variance in these ideas which makes the future hopeful and us, as professionals, potent. It gives us energy and causes us to repetitively reaffirm the soundness of our postulates and assumptions. It keeps us honest.

My concern today is that we may be becoming insensitive to too many questions; perhaps because there so many of us and we find confidence in our numbers. Or we may have turned our attention from primary issues to those of more personal or theoretical interest. We may be attempting to answer the question, "how can computers be used in education?" The answer to which is "many ways". We even have rather lengthy dichotomies and categorizations of the ways. People already speak of traditional! CAI--referring to the usual way of styling computer-assisted instruction lessons (without a very highly level of adaptiveness and with a lot of "page turning").

It may appear I'm suggesting that theoretical exploration is not important and neither is applied research... to which you respond "what's left?"

I'm not suggesting either of those things. Theoretical and applied research are not just important, they're vital. But, in my opinion, the high priority issues ADCIS members must face are:

1. defining the most significant educational and training problems to be solved

2. finding creative and logically superior solutions to those problems

3. comparing the outcomes of alternative solutions in a valid and persuasive manner

I'm developing a strong and nagging opinion that we're making little progess in the 1st and 3rd areas... not that no progress is being made and also not that more effective efforts can't be made in the second area. We tend, however, to focus the majority of our efforts on the solutions...we have beautiful solutions; if only they were applicable to our most serious concerns.

Note that I did not include in my list the item:

> determining how effective the computer can be in solving the identified problems

Although we have a special interest in computer solutions, it's not beneficial, not even to that interest, to overlook non-computer based media. We must be open to all alternatives, actively seeking and comparing alternative solutions.

1. defining the most significant educational and training problems to be solved

We all face the temptation to put high in our priority lists those problems which are most easily solved or are most interesting to solve, instead of carefully analyzing needs, defining specifically and operationally the problems and their origins, and prioritizing according to impact of the problem and value of the solution.

The needs lie in both theoretical and applied areas. They lie in areas of cost. They lie in areas of social responsibility. They lie in managing instructional institutions; in acquainting the public with the notion that mastery is better than grades, that learning is a life-long activity, that learning can be enjoyable, and that everyone can learn; and in training and retraining teachers.

Although the majority of CBI efforts focus on the delivery of individualized instruction, delivery mechanisms have evolved far more than have effective means of adaptive curriculum design. Some well worked adaptive models have been advanced, but finding affordable methods of curriculum development utilizing those models seem to be a formidable challenge.

We speak of easy-to-learn authoring languages. But I have to ask, easy to learn to do what? Few adaptive models are simple. We therefore require authoring languages which make highly complex logic easy to articulate. It doesn't matter if it's easy to program simple, superfluous things if it requires great expertise to carry out valuable operations.

I don't want to belabor this, because it's only an example of my point; but the computer must be considered one of a host of alternative media. If the instructional model is simple and also effective, it may very well be that it need not be computer-based for delivery. It bothers me very much to see CBI systems being used for rather trivial functions and then (and therefore) being judged too expensive by many. Used not as a novel supplement but in situations where CBI calculatedly and effectively provides a vital service, the costs look quite different. Cost effectiveness can be achieved by design--but rarely by accident...and this brings me back to my current point: it all lies in a careful definition and selection of the problems to be solved; if the problems being addressed are insignificant, the solutions to those problems will yield insignificant benefits.

2. finding creative and logically superior solutions to those problems

Much has been done to develop computer-based resources for education and training. In the last two years I have seen truly amazing work done in both expanding the capabilities of interactive systems and in reducing the level of expertise required to implement adaptive courseware. In my own work, we have written graphic display editors which give full editing control over the most complex displays to people with as little as 1/2 hour experience with the system. We have made it possible for people with typing ability, but no knowledge of interactive computing nor of computer programming, to control tailored diagnostic testing, to arrange for sophisticated prescription generation, and to analyze the comparative effectiveness of on- and offline instructional materials.

We have seen the successful introduction of home computers just this winter. Costs of processors and display units have dropped so significantly that hundreds of thousands of hobbyists can afford CRT displays--even while many CBI operations are still struggling to make the shift from slow teletypewriter terminals to faster and quieter display units.

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Similarly, in an area of great cost concern, we are seeing major advancements in communications capabilities such that one telephone line can service many more terminals than it previously could. This is being achieved through shared processing--with the terminal taking an increasing share of the load--and through improved multiplexing configurations. It's not difficult to project 100 or more terminals sharing the same line while providing extremely fast response time, access to large databases, and effective distribution of current courseware.

But have we made similar advances in educational technology as we have in software and hardware technologies?

Advanced computer capabilities haven't reduced the intellectual effort required to construct and test instructional models (although it has dramatically reduced the time of implementing and evaluating them). They haven't made it easy to design accurate diagnostic testing nor to deal with learning disabilities. They haven't alleviated the need for artistry and creativity in the preparation of effective and motivating instructional experiences. They haven't solved, as a matter of fact, very many of the toughest problems we face... but they have, perhaps for the first time, made it possible to make systematic progress toward the solution of some of society's most devastating inadequacies.

We're not in an easy business. And in one sense, it's not getting any easier...the broadening capabilities of our systems give us more and more opportunities. With more opportunities, it is increasingly important not to exhaustively try all possibilities. Adhering to the methods of science--advancing theories and using them as a basis for research--will undoubtedly prove a more effective strategy than random hit and miss development and evaluation. In devising solutions, we must moderate our interests in novelties and commit to solving the real--the tough--problems.

3. comparing the outcomes of alternative solutions in a valid and persuasive manner

Because the realm of possibilities is continuously and rapidly broadening, it's difficult to carefully and exhaustively test any instructional model at the sacrifice of moving on to the exploration of new potentials. As Editor of the JOURNAL of COMPUTER-BASED INSTRUCTION, it is my privilege to peruse many reports of on-going CBI activities. I have become concerned, however, at the volume of manuscripts which do not test a theoretical model, which do not seriously attempt to compare two or more procedures, and which do not even recognize current literature. These papers (while often of value) are actually reporting that some development was done because the developers found it personally challenging and possible within the confines of their hardware and software.

We know that CBI is exciting and often rewards ingenuity in observable hardware functions and user amazement. We even know that in many cases CBI has been effective in stimulating learning and has produced positive student attitudes. The questions we face are not: can the computer teach? can the computer simulate human instruction? The questions are what makes one instructional approach more effective for an individual than another?, how can we predict which approach will be most effective?, and what are the most efficient delivery media for the most effective approaches?

The replication of experiments is important to determine the stability and generality of findings, but the value of replication is scant without careful delineation of equivalencies and differences in the experimental and control variables. It appears that communication among us is so poor that writers are often unaware of related works and write as though their studies were pioneering efforts.

it may well be that other professions and disciplines may be characterized similarly, but I honestly feel ours is unparalleled in aspiration and dedication on one hand and informality and lack of rigor on the other. ADCIS legitimately represents more of application than theoretical research and is much concerned with development, but technology is not separate from science--it is part of it--professing the same methods of objective investigation and serving to provide vital feedback for theoretical research validation and direction (see Schaffarzick and Hampson, 1975).

whether there is (or can be) a science of teaching is a wonderful debate; but whatever the answer, there is most definitely an art to science. Some scientists are more successful than others, more published than others, more respected than others, and so on. Some have more funding opportunities than they can handle, others with at least equal research prowess and perhaps greater insight cannot get minimal recognition. There is obvious truth to the statement that knowing the right people helps. Having the respect of colleagues (even just having them aware of your work) and publishing are definite benefits.

ADCIS as an organization is helpful in many ways to everyone in the field. It gives us an opportunity to develop individually the art of being professionals--technicians--scientists. It helps draw attention to our collective efforts to advance the technology. ADCIS has responded rapidly and effectively to requests for special professional support, both monetarily and professionally. It has taken on the heavy burden of publishing the JOURNAL OF COMPUTER-BASED INSTRUCTION (JCBI), supported the Health Education Network Users Group, and underwritten partial costs of producing the INDEX TO COMPUTERIZED TEACHING IN THE HEALTH SCIENCES, as examples. And ADCIS has much more to offer.

Let me reiterate the three issues I've discussed to see how we might use our organization to further efforts in those areas:

1. With respect to defining the most important problems to be solved and challenges to be met, no single list nor prioritization of items seems either realistic or desirable; but ADCIS has divisions based on special interests and/or target student populations: Health Sciences, Elementary-

Secondary-Jr. College, Minicomputer Users, PLATO Users, Health Education Network Users, Music Instruction, and Education of the Deaf. I'd like to see these divisions work out within themselves the highest priority problems they face and questions they need to have answered.

2. With respect to discovering creative and effective solutions or methods for discovering such solutions, ADCIS could establish an "Outstanding Researcher" award and organize an appropriate selection committee. The committee could serve to single out those individuals who have not only successfully leveled their efforts at significant problems, but have also recognized and built on the work of others and have communicated the results of their investigations in a professional manner for the benefit of the CBI community. Hopefully such awards would encourage emulation of the professional attitude and establish a trend toward increased value of all CBI investigations.

We have many among us who are indeed worthy of such an award. Recognition of their efforts would most certainly prove beneficial to the continuation of their work as well as help broaden the impact of their studies. As a function of these awards, we might also hope for increased awareness of ADCIS as an organization and broadened recognition of its purpose and function as a professional society.

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3. Finally, with respect to the need for comparing outcomes of alternative instructional treatments, let me state what most of you are painfully aware of: controlled research in our field is difficult to orchestrate, time consuming, and expensive. Refining experimental designs so that the results will be specific enough to be useful and yet general enough to be broadly applicable can be very costly, but not having such data is very costly as well.

ADCIS could formally encourage research in priority areas, if not by direct funding, then perhaps, by serving as a catalyst for the formation of consortia (this has already happened once--the Health Education Network Users' group was formed for just such a function), by requesting that research grant proposals be written on the vital topics and then serving to facilitate their funding, by holding workshops in which multi-institution experiments and research projects are designed, by publishing special JCBI issues on the topics, etc.

There is an art to the career of a scientist. It involves experimentation, writing research reports, preparing grant proposals, and an objective attitude. Membership in key professional organizations can provide important benefits. I'd like ADCIS to be the most important organization for people in the field of computer-based instruction. We need ADCIS and ADCIS can serve us in powerful ways.

ADCIS can help strengthen communication and sharing of ideas. It can help us assume a more scientific and objective posture. The need is real and urgent. I am not suggesting that systematic investigation should or can substitute for enthusiastic insight and creative exploration; but I do think we need to make sure we are taking every step possible to ensure the value of each exploratory effort.

Prof. Bruce Sherwood, a physicist and prominent CBI investigator with whom it is my honor to be friend and colleague, stated the situation aptly when he said, "In physics we stand on the shoulders of such giants as Galileo, Newton, and Einstein; in CBI we're standing on each other's feet!" I think not only can we get off each other's toes, but we can also march effectively against many of the enemies of effective humanistic adaptive instruction by strengthening our Association and by developing our science arts.

REFERENCE

Schaffarzick, J. and D. H. Hampson: STRATEGIES FOR CURRICULUM DEVELOPMENT. Berkeley, Calif. McCutcheon, 1975.

BASIC SKILLS MATHEMATICS CURRICULUM
DEVELOPMENT FOR CBE

A Paper for a Topic Presentation
at the ADCIS Annual 1978 Conference
Dallas, Texas
March, 1978

by

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BASIC SKILLS MATHEMATICS CURRICULUM DEVELOPMENT FOR COMPUTER-BASED EDUCATION

The purpose of this paper is to describe the anatomy of the Basic Skills Learning System, a comprehensive curriculum development effort undertaken by the authors and funded totally by the Control Data Education Company. The Basic Skills Learning System was designed to deliver a variety of curricular materials via the PLATO System in the three content areas of Reading, Language and Mathematics. This discussion will focus primarily on the Basic Mathematics curriculum, as an example of the type of instructional material and strategy used throughout the Learning System.

This paper is organized into two sections; the design criteria established for the Learning System and the anatomy of the mathematics curriculum component of the Learning System.

DESIGN CRITERIA FOR THE LEARNING SYSTEM

The broad differences in chronological age, life experiences, and physical and mental health found in this population combine to provide variations in motivational levels and learning rates. An instructional program capable of responding to differences as great as these must use individualized instructional techniques to be successful. The Basic Skills Learning System was designed to deliver individualized, criterion-referenced instruction based on the "mastery learning" approach in a computer based educational learning environment. The system was constructed to fulfill the following requirements:

1. the system must be totally individualized and offers a highly adaptive and responsive learning environment;
2. the individual curricula must be modularized and structured in coherent, hierarchical patterns;
3. the intended learning outcomes of the System must be carefully articulated in terms of performance objectives;
4. The mastery learning paradigm must be employed as a basis for advance;
5. diagnostic and prescriptive strategies must be utilized;
6. a multi-sensory learning format must be employed.

Addressing each of these six criteria in order will reveal how the Basic Skills Learning System accommodated the individual requirements while resulting in a comprehensive system of "courseware".

Criteria Number 1: the system must be totally individualized and offers a highly adaptive and responsive learning environment.

The use of the sophisticated capabilities of the PLATO System which allowed the interaction of the instructions to take into account each and every student response. The materials developed for the Basic Skills Learning System was designed to adapt the amount and extent of instruction to the individual needs of each student. The common techniques usually employed in CAI "courseware" of self-pacing and individualized branching were further augmented by the ability of the Learning System to handle student controlled selection of instructional techniques while providing for a tailoring of teaching to individual performance. Immediate feedback is provided for each student based on his or her responses. Learners are helped to select the pathway through the material which is most appropriate for their reeds.

Criteria Number 2: the individual curricula must be modularized and structured in coherent, hierarchical patterns.

The flexibility of the curriculum lies in its ability to present to the learner a cohesive, comprehensive curriculum organized in a hierarchy of skills from the simple to the more complex. The Basic Skills Learning System curriculum materials specifically address each and every necessary skill in the defined content areas in a manner that does not leave topics unattended or require extensive instruction in any topics already mastered. One of the critical design premises is that students will not be presented instruction on topics for which they have not demonstrated competency in the prerequisite entry skills. This reduces student frustration and increases curriculum effectiveness. Instruction is presented in small, well-defined units which are less intimidating to students than large blocks of material.

Criteria Number 3: the intended learning outcomes of the System must be carefully articulated in terms of performance objectives.

Students begin with the simplest objectives, and progress to the most complex; this approach minimizes student frustration, and allows students to measure their own success and progress. The accuracy of the curriculum is based primarily on the specific definition of the objective in terms of performance competencies. When one takes into account the target population's desire to acquire skills necessary for improvement of their basic skills to lead to better employment possibilities, one is lead directly to consider only performance objectives which are directly related to skills necessary to perform in the working world.

Criteria Number 4: the mastery learning paradigm must be employed as a basis of advance.

The effectiveness of the curriculum is directly a result of the employment of the Mastery Learning Paradigm. The fundamental approach requires that students demonstrate mastery of each basic skill before work in a higher order skill dependent on that prerequisite skills is allowed. This commitment to the mastery learning model is responsible for the effective assignment of students to the material most appropriate to their capabilities at any given point in the instructional process. This model minimizes student frustration and enhances learner success because the most efficient use is made of the student's time.

Criteria Number 5: diagnostic and prescriptive strategies must be utilized.

The efficiency of the system is due primarily to the diagnostic inventory made of the skills of each entering learner. Each incoming student is assessed to identify skill deficiencies. This information is used to place each student appropriately within the curriculum and to direct learners to the instructional material most appropriate to their needs. The system continuously prescribes the list of available lesson strategies for a given Cluster of objectives within the Strand on which the student is currently working.

Criteria Number 6: a multi-sensory learning format must be employed.

The motivational acceptance of the Learning System is a result of extensive use of the interactive Control Data PLATO system, integrated with a multi-media support package. This multi-sensory approach is often successful with students who have difficulty achieving in text-oriented, passive learning environments.

The result-benefit of meeting each of the six stated criteria can be stated through the use of individualization strategies the Learning System becomes responsive to individual learners, through the modularized organization it becomes flexible to various learning environments, through a well organized objective base the system delivers instruction more accurately, through the use of the Mastery Learning Paradigm it is more effective in guaranteeing learning, through a diagnostic and prescriptive structure the system is much more efficient of the learner's time, and through the use of multi-sensory materials it is more motivating.

THE ANATOMY OF THE CURRICULUM

The Basic Skills curriculum encompasses three major content areas: mathematics, reading, and language skills. Each of these independent content areas is organized according to the following hierarchy:

- Objective: The objective is the smallest unit of instruction directly related to a measurable competency.
- Cluster: Objectives are organized into meaningful subsets, called clusters, according to the basic concepts with which they deal.
- Bundle: Interrelated clusters of objectives are packaged into bundles of objectives. A bundle is a grouping of clusters across which mixed practice is meaningful and retention is measured.

Strand: A strand is a major subset of the content with a conceptual thread throughout. The nine strands in the mathematics curriculum are:

- Basic Number Ideas
- Addition
- Subtraction
- Multiplication
- Division
- Fractions
- Decimals
- Ratio-Proportion-Percent
- Geometry and Measurement

This discussion will focus on one of the strands in the mathematics curriculum, as an example of how each of the elements of the curriculum fit together.

The Fractions strand is composed of 38 specific performance objectives organized into 15 meaningful clusters. Each of these clusters consists of the following set of instruction activities: a tutorial lesson, a drill and practice lesson, a set of exercises in the student Strand Booklet, a mastery test, and a review help sequence. The clusters are further grouped into three major bundles where a mixed practice, an applications activity, and a retention test are administered. The strand takes on the following precise description:

CURRICULUM: Basic Math Skills for Adults

STRAND: Fractions

Bundle A. Basic Terminology and Concepts
  Cluster 1. The Meaning of a Fraction
  Cluster 2. Basic Terminology
  Cluster 3. The Concept of Equivalence
  Cluster 4. Comparing Fractional Numbers
  Cluster 5. Improper Fractions and Mixed Numbers
Bundle B. Addition and Subtraction
  Cluster 6. Adding and Subtracting Fractional Numbers Having the Same Denominator
  Cluster 7. Adding and Subtracting Fractional Numbers Having Different Denominators
  Cluster 8. Addition of Mixed Numbers
  Cluster 9. Subtraction of Mixed Numbers in Instances Which Do Not Require Regrouping
  Cluster 10. Subtraction of Mixed Numbers in Instances Which Require No Regrouping
Bundle C. Multiplication and Division
  Cluster 11. Multiplication of Fractional Numbers
  Cluster 12. Division of Fractional Numbers in Simple Cases
  Cluster 13. Division of Fractional Numbers in General Cases

Cluster 14. Multiplication of a Mixed Number and a Whole Number

Cluster 15. Multiplication and Division of Mixed Numbers

CONCLUSION

The Basic Skills Learning System constitutes an attempt to develop a comprehensive package for dealing with a significant educational problem. It is being constructed under conditions of a common and coordinated instructional design. Accordingly it should be possible to reap not only economic benefits from this strategy, but curricular advantages as well. It is believed that such efforts are necessary for advance in the Computer-Based Education realm.

COMPUTER-BASED INSTRUCTION in an OUTREACH PROGRAM

by

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ABSTRACT

The project described here is developing a model curriculum delivery system to meet a special need. Small businesses usually fail because the principals lack management skills. Training in these skills is widely available but non-traditional curriculum delivery methods are needed to bring the training to the business owner at his location, time, and place rather than at the location, time and place of the training institution.

This overview describes an educational system for training small business owners which will deliver the instruction at the convenience of the student - and be effective. We are developing a modular curriculum for delivery via video cassette, text, and computer terminal which will effectively train the small business owner at his pace and which will also serve as a model for a flexible multimedia educational system built around a digital computer.

INTRODUCTION

The main thrust of this project is the development and evaluation of a curriculum delivery system which combines the advantages of computer assisted instruction (CAI) for individualizing and monitoring student progress with the advantages of Educational Television (ETV) for vividness in presenting material. In addition, the project is focusing on developing a modular curriculum to meet the need of small business owners for training in management skills.

The final product of this project will be a modularized curriculum available through video cassettes (for lectures, etc.), texts (for detailed explanations and exercises) and computer terminals (for detailed exercises, evaluation and monitoring progress) at locations and times convenient to the student.

Background of the Problem

There are many areas of instruction that require a non-traditional approach to the delivery of the necessary curriculum. One of these areas is the training of small business owners in the management skills they need in order to succeed. Traditional instruction can provide these skills but it is only available if the small business owner can place himself regularly where the instruction is given. This is often impossible because the nature of the small business enterprise places great demands on time and makes scheduling time away from the work on a regular basis impossible.

A curriculum delivery system for this population should take full advantage of the current capabilities of technology to provide flexibly available and individualized educational opportunity, so that those in need of the instruction can receive it on their time schedule and at their pace.

For many months, the College of Business Administration at the University of San Francisco worked with the San Francisco Office of the Small Business Administration in developing Special Management Training Courses for Asian-American and Latino-American small entrepreneurs. These courses were well received. However, our discussions with the participants indicated a need for a curriculum delivery system that went even further outside the traditional classroom approach.

In a survey of the participants in the Special Management Training Course for Asian-American small businesses (Lorton, Ma & Sam) suggestions for improvement of the course were solicited. The participants wanted more attention to their individual problems, more active participation with some of the topics covered and a modification in the meeting schedule. On this last point there was little agreement on the type of modification since every respondent had different demands on time, different preferences for days, etc.

The kind of curriculum delivery system these small business owners need is one which allows them to participate on a schedule they can determine and one which maximizes the individual attention and practice they can receive. These needs are not unique to this application and, if met, could help provide a model curriculum delivery system for other applications.

Nature of the Solution.

What is needed is an open entrance - open exit training program with intensive individualization of instruction and a high level of active participation by the student. We feel that educational television in conjunction with computer assisted instruction can provide this.

In response to this problem, we developed a project with the following intended activities:

1. Test and evaluation of the combination of CAI and ETV in delivering curriculum;

2. Test and evaluation of a modular curriculum for management training of small business owners.

The project will produce:

1. An effective, modular curriculum for management training for small business owners which could be implemented at little cost in many locations;

2. A model for a curriculum delivery system which could be adapted to many areas where training of inplace personnel is needed and must be scheduled according to their availability rather than according to the availability of instructors.

The evaluation of the effectiveness of the curriculum will be accomplished by monitoring the business performance of the students. We have some preliminary experience in developing a method for evaluating the effectiveness of management assistance to minority owned small businesses (see Cammarota & Montefusco or Cammarota, Lorton & Montefusco) and will apply the methods of that experience to this project.

The dissemination of this curriculum is also important to the solution as it confirms the strength of the model curriculum system. We expect workable dissemination to be one outcome. Text and video cassette material are easily moved from one place to another. The computer delivered material adds extremely important dimensions of pacing, performance monitoring and active interaction to the curriculum. We are working toward transportability of this material by developing it in a widely available computer language and on a computer system in widespread use in educational institutions.

DESCRIPTION OF THE PROJECT

This project has been funded by the Fund for the Improvement of Post Secondary Education and is currently in operation in the San Francisco area. This is the final year of the project and the preliminary response from those specifically concerned (small business owners, personnel at the Small Business Administration) has been quite positive. In addition other members of the business community as well as members of the educational community have expressed strong interest in trying to fit this educational system to their needs.

Project Scope

The project has two facets. The first is testing a curriculum delivery system which will provide an open-entry training environment through the combination of computer-assisted instruction and educational television. The second facet is the development of a modular curriculum for the specific application of management training for small businessmen.

Curriculum Delivery System.

Two main facilities are being used. The EDP Resource Center of USF's College of Business Administration is being used for the computing resource. The Educational TV Center of the Archdiocese of San Francisco is providing the television resource as well as the remote sites for the instruction.

The EDP Resource Center has been used for a number of computer assisted and computer aided instructional applications. Several courses in the College of Business make heavy use of the computer both as a computer, per se, and as a source of instruction. One course has been developed for an outside agency (see Lorton & Reyes, 1975) where students from the Defense Contract Services Region - San Francisco spend two weeks in an intensive course on computer programming for Automatic Test Systems. The experience and facilities of this Center was used to produce the computer assisted instruction components as well as the progress monitoring capability.

The Educational TV Center of the Archdiocese of San Francisco has implemented and refined an Instructional Television Fixed Service (ITFS) network. This system provides microwave TV transmission to 55 elementary and eight secondary schools throughout the San Francisco Bay Area. The ETV center contributed the expertise gained from experience to assist in producing the video portion of the modular curriculum.

Modular Curriculum for Management Training of Small Businesspersons

The curriculum is being developed to parallel the curriculum already started for the special management training institutes developed in conjunction with the Small Business Administration.

The curriculum includes the following topics:

Title	approx. hours
Accounting and Taxation for the Small Business	15
Financial Analysis for the Small Business	5
Legal Aspects of Small Business	5
Obtaining Funding and Assistance	5
Sales and Marketing for Small Businesses	10
Labor and Personnel Issues in Small Businesses	5
Planning for the Future	5
Total	50 hours

Our experience with the Special Training Institutes and with surveys of small business owners indicates that these topics constitute the essence of the content needed. The approximate duration represents the instructional time which various faculty members think is required for each topic in a course of this nature.

System Operation

At each site is a video cassette player and a number of terminals linked to the computer system located at the University of San Francisco. Students come into these centers when their schedules permit and work at their own pace through a variety of possible activities. A student may choose to view a video cassette on financial analysis then sign on to the computer system and practice the concepts discussed in the video material. The student may be working on an exercise in his text and may want to check his progress with the computer. The student may also be continuing a sequence of drills in basic accounting concepts or he may have a specific problem from his business and may want to use the computer as an aid in its solution.

The system is designed to be as flexible as possible in order to conform to the needs of the student and to his pace. A student may have difficulty with English and want to review the Accounting (the Language of Business) video material several times going between the drills on the terminal and the video tape until he feels he solidly understands this fundamental area.

Project activities

Development of Curriculum Modules

The first phase of the project was devoted to initial development of the curriculum modules for the project. These consist of scripts for video lectures and the necessary text material to complete the presentation of the topics. Computer programs are providing computer assisted instruction in each topic area as well as exercises and activities to enable monitoring of student progress. The progress monitoring function is developed to parallel the video scripts and text material.

Initial Test Period

The initial test period was used to refine--in close conjunction with the students--the material developed in the first phase.

Revision of Curriculum and Production of Video Cassettes

The three-month summer period between the first and second year of the project was devoted to a thorough revision of the curriculum materials. At the end of this period, the curriculum materials were produced in the format to be used for the test and evaluation phase of this project. (The final form will be produced after the fourth phase of the project).

Final Test and Evaluation

The final test and evaluation constitutes the last major phase of the project. During this phase the curriculum delivery system will consist of video cassettes and computer terminal time made available at selected ITFS network sites during a range of hours determined by the students.

In addition to evaluation of the curriculum and system through tests and questionnaires given to the participants, we will monitor and evaluate actual practices of the small business owners, to see if the lessons contained in the curriculum are being used in the most effective way.

PROSPECTS

The project described here is an attempt to meet a growing need as educational institutions move to serve non-traditional populations effectively and at reasonable cost. In addition, we feel it has implications as a model for a computer based curriculum delivery system.

It is within easily available current technology to use the material we are developing in a library type setting. That is, once the material is finished it could well be placed in a location where cassettes, players and terminals could be drawn from a library and used in the home.

Because the monitoring is done by computer and the student sets his schedule and pace, the location where the instruction is given is no constraint at all. This means that no one potential student would be excluded from being able to secure the instruction he needs - it can truly be delivered to him.

The prospects for this model of curriculum delivery using technology which will become easily available in the very near future are also excellent and exciting. Specifically the combination of micro processor based home computers (such as that used by Texas Instruments in their recently announced home television game apparatus) and Video Discs are ideally suited to adoption for use by the educational system modelled in this project.

Our experience with this project has given us cause to be quite optimistic on the view that computer based technology is on the threshold of finally revolutionizing education by extending opportunities without limit beyond the traditional facilities and methods.

ACKNOWLEDGMENT

We would like to acknowledge the work of the ETV Center on thi project and the Fund for the Improvement of Post Secondary Education whose support has made the system possible.

REFERENCES

Cammarota, Q. & Montefusco, D. "Evaluation of Management Assistance to Minority Owned Small Businesses." Unpublished MBA Thesis. University of San Francisco, 1976

Cammarota, Q., Lorton, P. & Montefusco, D. "A Procedure for Evaluation of Management Assistance to Small Businesses." In preparation.

Lorton, P., Ma, P. & Sam, D. "Asian-American Businesses in the San Francisco Bay Area: A Preliminary Report on Problems and Prospects." In preparation.

Lorton, P & Reyes, E. "Meeting the training needs of quality assurance personnel in computer programming for Automatic Test Systems." International Conference on Advances in Automatic Testing Technology. (IERE Conference Proceedings #30), London, 1975.

SUMMARY OF VIDEO MATERIAL

0. Introduction
   1. How to Use this Course - Lorton, Muscat & Lazarus
   2. The American Dream - Roy Worthington

I. Accounting and Taxation for the Small Businessperson
   1. Introduction to Accounting - David Weiner
   2. Introduction to Taxation - Marc Lumer
   3. Tax Hints for Small Businesses - Michael Thompson
   4. The Language of Business - SBA Film

II. Financial Analysis for the Small Businessperson
   1. Financial Ratios - David Weiner
   2. Cash Flow - Bonnie Moore
   3. The Heartbeat of Business - SBA film

III. Legal Aspects of Small Business
   1. Introduction - David Scalise
   2. Legal Structures for Small Businesses - Pam Rohan

IV. Obtaining Funding and Assistance
   1. Suggestions from a Banker - First Enterprise Bank
   2. Banking and Small Business - Hal Walt

V. Sales and Marketing for Small Businesses
   1. Concerns of the Market - William Regan
   2. Introduction to Marketing - Karl Boedecker
   3. Franchising - Roger O'Callaghan
   4. Personal Selling - Brad Fregger

VI. Labor and Personnel Issues in Small Businesses
   1. Some Union Issues - Muscat Bros.
   2. OED Compliance - Ernie Reyes
   3. Behavior in Organizations - Nick Imparato
   4. Personnel Issues - N. Imparato & Larry Murphy
   5. Affirmative Action and the SBA - Eugene Brown

VII. Planning
   1. Planning for the Future - Paul Lorton, Jr.
   2. The Calendar Game - SBA Film
   3. The Business Plan - SBA Film

VIII. General Business Issues & Problems
   1. Overview of a Small Business - Czalsaw Orycz
   2. Office Management - Raymond Jones
   3. Overview of Small Business Practice - Stewart Krackover
   4. Personal Concerns in Small Businesses - Czeslaw Orycz

   5-6. Women in Business - Two "Woman" PBS programs

   7. The Family in Business - Circle Cleaners

SUMMARY OF C. A. I. MATERIAL

1. Accounting and Taxation
    a. Accounting terms
    b. Exercises in the Balance Sheet
    c. Exercises in the Income Statement
    d. Tax Concepts

2. Financial Analysis
    a. Financial Ratios
    b. Seasonal Variations

3. Legal Aspects
    a. Laws in Business
    b. Forms of Business Organizations
    c. Workmen's Compensation

4. Obtaining Funding
    a. Preparing a Prospectus
    b. Sources of Funding

5. Sales and Marketing
    a. Pricing Policies
    b. Marketing Simulation
    c. Sales and Marketing Concepts and Terms
    d. Marketing Surveys

6. Labor and Personnel Issues
    a. Personnel Policy
    b. EEO and Affirmative Action

7. Planning
    a. Steps in Planning
    b. Concepts in a Business Plan
    c. Forcasting Methods
    d. Risk Taking

8. Support Programs
    a. SBA Literature Summaries
    b. Course Guide

Factors in Time-Variable Learning
Allowed by Computer Delivered
Interactive Testing

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30 September 1977

Abstract

Students undergoing a mastery-variable time-variable undergraduate educational psychology course were studied in order to determine the effects of level of mastery chosen (final grade) on time to criterion over five course examinations. When equated for trials to criterion, no such grade aspiration effect was found. A factor analysis of 23 course-related measures found time allowed for learning an important source of variation in a Mastery Learning teaching strategy while academic aptitude was relatively unimportant. The study demonstrated how low-cost microcomputers can provide time flexibility in school curriculum.

Factors in Time-Variable Learning Allowed by Computer Delivered Interactive Testing

Introduction

For a number of years researchers have expressed the importance of time allowed for learning as an important variable in explaining school achievement (Carroll, 1962; Glaser, 1967; Atkinson, 1967; Spady, 1977). Bloom (1976) has estimated that time, when combined with other such cognitive entry behaviors as intelligence and perseverance, may account for as much as 50 percent of the variation in school achievement. Traditional school learning shows great variation in student achievement when the time allowed for learning is fixed. This variation represents the individual differences which have been a problem for educators. If time allowed for learning is an important reason for these individual differences, one might conjecture that if it were allowed to vary in accordance with individual needs, some of the achievement variance would disappear.

Carroll (In Block, 1971) estimates that the ratio of slow-to-fast-learner time to criterion is about 5 to 1. He also suggests that this ratio can be diminished through sustained Mastery Learning teaching strategies. Anderson (1976) confirms this ratio, as well as its reducability.

In the present study, a Mastery Learning strategy was operating in an existing course. It attempted to isolate salient variables which would explain student activity. Microcomputer technology allowed time and trials to criterion to vary in a manner not allowed in other courses.

In this strategy, since mastery is fixed at three levels, there should be little variation in student achievement within each level; thus, it was hypothesized that fixed levels of mastery would allow great variation in time to criterion. If time to criterion were to be an important variable in explaining results of a college-level Mastery Learning strategy, then level of the criterion and trails to criterion should be important causes of this time variation. Academic aptitude should be a poor predictor of time to criterion, but a good predictor of achievement level in the Mastery Learning instructional strategy.

Method

Subjects

Forty-two students who completed an undergraduate liberal arts teacher education course were studied. Eight of the original class of 50 did not complete the course within the semester, and were dropped from the investigation. The group A.C.T. scores ranged from 13 to 31 with a mean of 22.83. Of the 42 students who completed the course in 107 days, 14 aspired to an "A", 22 to a "B", and six to a "C".

Procedure

The students were enrolled in a three semester hour educational psychology course using the Biehler (1974) text and five accompanying test item pools. During the 16 week semester, students spent one hour and fifteen minutes in class and three hours assigned to an elementary school classroom as a teacher aid. Class discussion topics followed text assignments, and students were required to make appointments for the five course examinations on their own time. Examinations were administered via a cathode ray tube screen of an IBM 5100 portable computer. Each examination consisted of 15 multiple-choice questions randomly selected from one of the five item pools. If a choice was incorrect, the computer responded with "TRY AGAIN," and the question was presented again. This procedure would continue until a correct answer was chosen, when it would respond, "OK, SALLY, BUT BE SURE TO READ FEEDBACK FRAME." If Sally responded correctly on the first try, a random superlative would be presented, such as "EXCELLENT, SALLY." Examinations were scored with partial credit points on a 3-2-1-0 basis, depending on the number of choices required to get a correct answer. After 15 such iterations, scores were presented, with the criteria for letter grades of A-B-C-D being 90-80-70-60 percent, respectively. If students were not satisfied with their grades, they could see the instructor for aid, re-read the two or three chapters, and sign up for another randomly-selected set of questions from the item pool. Students could follow this procedure three times, if necessary, for each of the five examinations. This was the second full semester this treatment was utilized, and the procedure was only refined from that described in an earlier paper (Evans and Surkan, 1977), which examined achievement scores as a dependent variable.

Variables

Measures available for study included sex, age, A.C.T. Composite scores, the four 16PF Second Order Factor scores of Extraversion, Anxiety, Tough Poise, and Independence and final grade. Testing measures included trials to criterion, and highest raw score on each of the five course examinations.

Design

The research plan was to examine the effect of the three levels of final grade aspiration on days to criterion on each of the five examinations. Then, if significant effects were found, to study the relationship of trials to criterion with this variable. Finally, an exploratory study of the relationship among all 23 of the measures available was to be conducted. The .05 alpha level was chosen as the criterion for statistical significance.

Results

The ratio of highest to lowest number of days to criterion for each of the five examinations was, respectively, 3.45:1, 3.58:1, 3.03:1, 2.09:1, and 1.77:1.

Univariate analysis of variance of the three levels of final grade aspiration on time (days) to criterion revealed significant differences ($P < .01$) on examinations two through five. Figure 1 gives a plot of these mean score values.

Insert Figure 1 about here

Next, a comparison of the trials to criterion for each of these tests was obtained for each of the three levels of final grade.

Insert Table 1 about here

Table 1 presents the mean trials for each group. Although the mean total trials for each examination gives some indication of the relative difficulty of the five examinations these differences were not found to be important (Chi Square = 0.07, df = 4, n.s.). A test of the differences in total trials for each level of final grade was also unimportant (Chi Square = 5.43, df = 4, n.s.). Since trials was unrelated to grade, a reexamination of the effect of grade on days was conducted using trials as a covariate. Here, the significant differences among the means tended to disappear, with the differences among the three levels of grade remaining significant on only the second examination.

In order to observe the relationships of the foregoing variables with other measures available, intercorrelations are presented in Table 2.

Insert Table 2 about here

Here, it may be seen that final grade was negatively related to trials and days on four of the examinations, positively related to raw scores, and unrelated to A.C.T. aptitude test scores. The results of a factor analysis of these 23 measures is shown in Table 3.

Insert Table 3 about here

The findings of this analysis should be interpreted with caution since the number of cases is small. Seven factors appeared and are listed in their order of importance with tentative names.

Discussion

The ratios comparing days to criterion of slowest to fastest student on the five examinations are somewhat lower than that found by Anderson (1976), and there appears to be a distinct diminishment of this ratio as the course progressed. The lower overall ratio may be explained by the more homogeneous group allowed by the screening process of selecting candidates for teacher education in a private liberal arts college. It is tempting to explain the general diminishment in the ratio, from 3.58 to 1 on the first examination to 1.77 to 1 on the fifth as an alterable human characteristic due to the Mastery Learning teaching strategy in the manner of Anderson's findings. However, a problem without control in the present investigation was the subtle pressure of the registrar's office to turn in a grade at the end of the semester. This, along with the eight students who did not finish within the semester may have accounted for the greater homogeneity of the class in time to criterion on the last two examinations.

The relationship between level of final grade (A-B-C) and days to criterion seems logical. Students who aspired to the higher course achievement levels required less time than those whose aspirations were not so high. What is more difficult to explain is the addition of trials as a covariate in this analysis and its effect on minimizing these grade differences in days to criterion. This enjoins a search elsewhere for explanation of this time to criterion variance. The factor analysis may provide some clues. Time-related variables, as well as anxiety and independence, correlated highest with the second most important factor (II) in the factor analysis. The lack of a relationship between A.C.T. scores and this factor is also noteworthy. Further investigation of this time variance should control for the foregoing personality characteristics.

While factor I accounted for nearly 40 percent of the total class variation, mostly due to the high relationships between raw scores on tests and final grade, this result is minimized when remembering that there were three levels of mastery in the course--required by the college's traditional letter grading system. As indicated above, this effect is minimized when controlling for grade aspiration and trials.

Factors III, IV, and V appear to be most related to the personality measures. Factor VI seems to be a "learning how to take interactive mastery tests" phenomenon, since it correlates highest with trials, days, and score on the first examination, and diminishes thereafter.

While the hypothesis concerning the effect of the three levels of mastery on time to criterion cannot be accepted due to the confounding effect of trials, it is possible to conclude that time is an important variable in school learning. The communalities (h^2) of the days-to-criterion variables are consistently among the highest of the 23 variables. This importance supports the notions of the Carroll "Model School Learning" (1962) and Bloom's "Mastery Learning" (In Block, 1971) that time allowed for learning varies according to individual human characteristics, and if schools really wish to maximize the achievement of all students, they must be able to adjust the time allowed for learning. The low-cost microcomputer used in the present study has possibilities for allowing students time flexibility in undertaking tasks when they are ready. The Carnegie unit and the semester-hour of credit, both fixed units of time, do not allow students to transcend the bounds of the grading period or semester. The technology and process demonstrated in this study give an indication of how time-variable learning would be possible.

References

Anderson, L. W. An empirical investigation of individual differences in time to learn. *Journal of Educational Psychology*, 1976, *68*, 226-233.

Atkinson, R. C. Computer-based instruction in initial reading. *Proceedings, 1967 Invitational Conference on Testing Problems.* Princeton: Educational Testing Service, 1968

Biehler, R. F. Instructors Manual, *Psychology Applied to Teaching*, Second Edition. Boston: Houghton Mifflin Company, 1974.

Block, J. H. *Mastery Learning, Theory and Practice*. New York: Holt, Rinehart and Winston, Inc., 1971.

Bloom, B. S. *Human Characteristics and School Learning*. New York: McCraw-Hill Book Company, 1976.

Carroll, J. B. A model of school learning. *Teachers College Record*, 1963, *64*, 723-733.

Evans, R. M., and Surkan, A. J. Effect of computer-delivered testing on achievement in a mastery learning course of study with partial scoring and variable pacing. *Proceedings, Eighth Conference on Computers in the Undergraduate Curricula*. East Lansing: Michigan State University, 1977

Glaser, R. Adapting the elementary school curriculum to individual performance. *Proceedings, 1967 Invitational Conference on Testing Problems*. Princeton: Educational Testing Service, 1967.

Spady, W. G. Competency based education: a bandwagon in search of a definition. *Educational Researcher*, 1977, *6*, 9-14.

Table 1

Mean trials to criterion of three levels

Of grade aspiration over five course examinations

Final grade	n	Examination					Total
		1	2	3	4	5	
A	14	1.79	1.36	1.93	2.00	1.43	8.50
B	22	1.77	2.09	2.14	1.86	1.55	9.41
C	6	2.33	1.83	2.17	2.00	2.00	10.33
Total	42	1.86	1.81	2.07	1.93	1.57	9.24

Table 2

Intercorrelations, Means, and Standard Deviation of 23 Course-Related Measures

Variable	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Sex	-.52	-.17	-.13	.03	.08	-.27	.00	.09	.13	.05	-.27	.29	.14
2. Age		.22	-.05	-.39	-.23	.46	-.17	-.12	-.18	.01	.12	-.18	-.22
3. ACT Score			-.19	.15	-.08	-.09	-.20	-.12	.30	-.09	-.08	.12	.08
4. Extraversion				-.32	.56	.13	.44	.02	-.16	.02	.23	.00	-.02
5. Anxiety					.06	-.26	-.04	.35	.14	-.05	.03	.04	.18
6. Tough Poise						.09	.18	.12	-.22	-.02	.44	-.06	-.06
7. Independence							-.17	-.06	-.14	.06	.38	-.24	.04
8. Trials, Test 1								.54	.02	-.10	.16	-.13	.09
9. Days, Test 1									.20	-.23	.12	.04	.01
10. Raw Score, Test 1										-.14	-.37	.38	-.10
11. Trials, Test 2											.36	-.26	.22
12. Days, Test 2												-.62	.17
13. Raw Score, Test 2													-.15
14. Trials, Test 3													
15. Days, Test 3													
16. Raw Score, Test 3													
17. Trials, Test 4													
18. Days, Test 4													
19. Raw Score, Test 4													
20. Trials, Test 5													
21. Days, Test 5													
22. Raw Score, Test 5													
23. Final Grade													

Table 2

(continued)

Variable	15	16	17	18	19	20	21	22	23	*M*	*SD*
1. Sex	-.07	.27	.11	-.33	.28	-.12	-.47	.40	.40	--	--
2. Age	.01	-.36	-.10	.19	-.29	.13	.30	-.27	-.32	19.90	1.56
3. ACT Score	.02	.01	-.07	.16	-.09	-.10	.30	.07	.00	22.83	4.61
4. Extraversion	-.09	.08	-.14	-.24	.16	.00	-.17	.01	.01	5.42	1.90
5. Anxiety	.31	.02	-.03	.26	-.06	.10	.29	-.08	-.09	5.34	2.07
6. Tough Poise	.10	.30	-.18	-.10	.26	.00	.06	.14	.14	5.07	1.71
7. Independence	.35	-.11	-.10	.18	-.02	.30	.32	-.31	-.17	5.78	1.52
8. Trials, Test 1	-.11	.07	.17	-.14	.02	.00	-.21	-.01	-.06	2.00	.91
9. Days, Test 1	.02	.21	.17	.02	.09	-.15	-.04	-.06	.11	31.67	17.92
10. Raw Score, Test 1	-.21	.30	-.11	-.11	.17	-.41	-.27	.07	.44	41.33	2.22
11. Trials, Test 2	.06	-.07	.08	.20	-.25	.22	.19	-.01	-.30	1.83	.79
12. Days, Test 2	.59	-.11	-.09	.52	-.21	.37	.60	-.36	-.48	46.80	17.33
13. Raw Score, Test 2	-.48	.26	.23	-.38	.40	-.38	-.47	.59	.67	41.10	3.24
14. Trials, Test 3	.42	-.14	.31	.41	-.18	.33	.31	-.13	-.24	2.07	.87
15. Days, Test 3		.23	-.33	.79	-.42	.20	.67	-.46	-.53	67.13	19.41
16. Raw Score, Test 3			.01	-.39	.63	-.01	-.43	.53	.77	40.30	3.20
17. Trials, Test 4				-.07	.23	.34	-.05	.22	.17	1.93	.91
18. Days, Test 4					-.50	.07	.81	-.50	-.59	82.63	16.80
19. Raw Score, Test 4						-.07	-.50	.45	.72	39.80	3.27
20. Trials, Test 5							.33	-.16	-.28	1.63	.81
21. Days, Test 5								-.46	-.64	93.87	14.98
22. Raw Score, Test 5									.70	40.83	2.88
23. Final Grade										3.37	.61

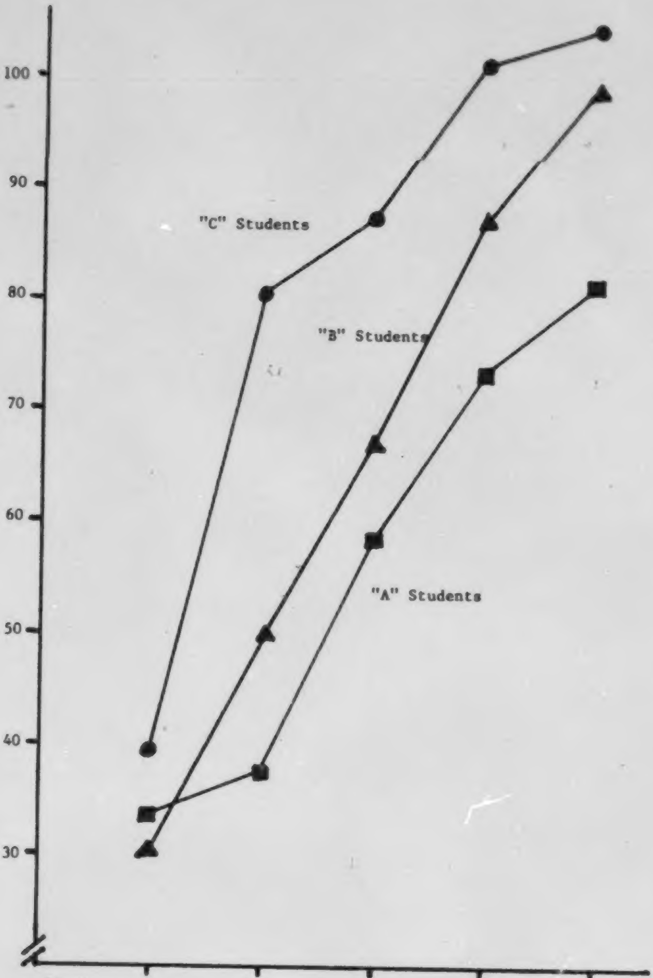
Table 3

Varimax Rotated Factor Matrix of twenty-three course-related variables

Variable	Factor							
	I	II	III	IV	V	VI	VII	
	"Mastery"	"Time"	"Toughness"	"Perseverance"	"Dependence"	"Naiveté"	"Aptitude"	h^2
Sex	.36	-.05	-.14	.03	.56	-.08	-.36	.60
Age	-.29	-.07	-.09	-.02	.76	-.10	.11	.71
A.C.T.	.02	.04	-.13	-.10	-.01	-.09	.59	.39
Extraversion	.01	-.16	.74	-.05	-.10	.11	-.16	.62
Anxiety	.02	.39	-.17	.02	.41	.24	.29	.49
Tough Poise	.29	.22	.77	-.04	.09	.02	.01	.74
Independence	.04	.35	.06	.10	-.65	-.09	-.16	.59
Trials 1	-.12	-.17	.37	.09	.13	.67	-.18	.69
Days 1	.13	.14	-.01	-.05	.08	.85	-.03	.77
Score 1	.27	-.09	-.30	-.38	.13	.20	.20	.41
Trials 2	-.19	.11	.10	.31	.07	-.25	-.08	.23
Days 2	-.20	.62	.49	.29	-.21	.06	-.03	.79
Score 2	.48	-.44	-.20	-.16	.20	.01	.23	.58
Trials 3	-.14	.30	-.07	.46	.27	.03	.05	.40
Days 3	-.28	.90	.01	.02	.04	-.05	-.01	.88
Score 3	.79	.00	.14	-.06	.12	.09	-.04	.66
Trials 4	.16	-.30	-.20	.74	.05	.24	.07	.77
Days 4	-.44	.65	-.11	.13	-.05	.01	.32	.76
Score 4	.75	.21	.11	.01	.01	.07	-.09	.63
Trials 5	-.04	.22	.05	.67	-.20	-.09	-.12	.57
Days 5	-.41	.64	.04	.27	-.22	-.07	.50	.95
Score 5	.58	-.40	.07	.06	.28	-.15	.10	.62
Grade	.91	-.32	-.08	-.17	.11	.04	.02	.99
Eigenvalue	5.85	2.27	1.99	1.50	1.40	1.09	.72	
Percent Variance	39.50	15.30	13.40	10.10	9.40	7.40	4.90	

Figure Caption

Figure 1. Days to criterion according to three levels of grade achievement over analysis of variance results.



Test:	1	2	3	4	5
Grade effect	n.s.	$p < .01$	$p < .01$	$p < .01$	$p < .01$
GE with covariate (Trials)	n.s	$p < .02$	n.s	n.s	n.s

The Lister Hill Center Plasma Terminal System and Implications for Medical Networks

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INTRODUCTION

The Lister Hill National Center for Biomedical Communication (LHNCBC) has supported a program to develop a Plasma Terminal System (PTS) for purposes of improving the effective delivery of computer based educational materials (CBEM). This system, employing recent advances in microprocessor and storage technologies, will provide new alternatives for present users of computer assisted instruction (CAI) networks. The purpose of this paper is twofold: (I) to present an overview of the Plasma Terminal System, and (II) to discuss some implications for medical networks.

I Plasma Terminal System (PTS)

A. Overview

Within the health sciences community, there are four computer assisted instruction (CAI) languages of major interest: PLATO/TUTOR (1), Coursewriter (2), MUMPS (3,4), and PILOT (5,6). Of these, PLATO/TUTOR is unique in its support of sophisticated computer generated graphics. As a consequence, while the other languages may be accessed by standard ASCII computer terminals, PLATO/TUTOR requires a specialized PLATO terminal (7,8). A growing number of health sciences educational institutions are utilizing PLATO courseware, as well as courseware available through local and network access in other CAI languages. Hence, one objective of the Lister Hill PTS was to develop a terminal that would be able to service multiple communications protocols, including PLATO and ASCII.

Another objective was to provide a graphics capability commensurate with PLATO for other CAI languages. The problem was not only the provision of a graphics capability, but the provision of same without the normally high host computer overhead. Just how this has been achieved will be discussed in the subsequent section on Design Philosophy.

The PILOT CAI language is unique in the wide range of its implementations; from large scale computers to microprocessors and stand-alone intelligent terminal systems. LHNCBC most recently supported the implementation of PILOT on the INTEL 8080 microprocessor, as well as an extended, multiuser version of PILOT on the Data General family of computers (MicroNova to Eclipse). The PTS has been designed to support PILOT in a stand-alone mode with full graphics capability. Provision has also been made for the utilization of other stand-alone microprocessor based CAI languages (e.g., MUMPS) with the PTS. This stand-alone capability will allow users to experiment with the development of new material as well as the modification of existing material without jeopardizing the integrity of programs in the network host or incurring expensive developmental costs.

While ancillary to this discussion, LHNCBC has initiated a study of PLATO graphics commands for purposes of defining an appropriate set of graphics primitives for the PTS. An initial report is available (9). A synthesis of the study conclusions will result in a recommendation to the community for CAI graphics language primitives to be used in conjunction with the PTS. The primitives are being defined so as to maximize the potential for translation of courseware from one CAI language to another.

B. Design Philosophy

The PTS development, from its inception, has been directed at providing a low-cost integrated terminal system capable of meeting the present, as well as future, interactive terminal requirements of existing CAI systems. As discussed earlier, PLATO is the graphics standard in the CAI environment. Therefore, the first PTS objective was to maintain compatibility with the PLATO V effort at the University of Illinois. The PLATO V concepts, however, do not directly parallel those developed for PTS. Although the PLATO V system takes advantage of the local processing power in the terminal, the latter is not intended to function in a stand-alone mode. That is, the PLATO V terminal can only operate in an on-line network environment. As discussed in An Interactive Graphics System Under MUMPS (11), existing CAI systems will require considerable modification to incorporate graphics generation into the host language. Further, most systems were not designed with the capacity to support a large number of interactive graphics terminals; and existing network environments do not provide the communications bandwidth desirable for true interactive graphics with animation. These "givens" heavily influenced the design of the PTS system.

The major emphasis during the PTS design was to maximize local processing capabilities. In order to provide a sophisticated interactive graphics system capable of functioning as a remote distributed terminal processor, to existing CAI systems, a flexible hardware/software design architecture was required. Most standard intelligent terminal systems are comprised of user input/output devices (plasma panel or CRT, keyboard, etc.) and communications hardware controlled by a single microprocessor. In the PTS, the complexity of locally generated graphics, stand-alone operation, and multiple remote computer communications protocols dictated the need for new concepts in terminal design. The software and hardware design concepts implemented in the PTS very closely parallel those presented in Principles of Interactive Computer Graphics (12) for dedicated graphics systems and Multiprocessor and Parallel Processing (13) for parallel processing systems. This design approach provides the modular framework necessary to migrate functions to dedicated microprocessor subsystems, within the PTS, as new processing/performance requirements are identified. Further, a unique protocol between the graphics primitives and the "outside world" was designed to facilitate interface to new micro/minicomputer systems.

Figure 1 provides a conceptual overview of the PTS hardware subsystems and their inter-relationships. Figure 2 shows the major software modules and their inter-relationships. It should be noted that the two microprocessors run asynchronously as a "directly coupled system" (13). This allows the Language Processor (PILOT) to run in parallel with the Graphics Command Processor, thereby improving the overall performance. This feature will become more important as new languages and stand-alone program sophistication are added to the PTS.

This design concept will provide a new dimension to the implementation of interactive CAI systems. As can be seen from Figures 1 and 2, the PTS design provides an unusually flexible interface capability for both remote and local applications. The following features attest to the flexibility of this design:

System Features

- A stand-alone set of graphics primitives that encompass the functions of the primary PLATO graphics commands as a subset.
- PLATO V compatible.
- A Graphics Primitive Language (GP/L) that is host language independent.
- An extended PILOT interpreter which includes GP/L syntax processing.
- A remote computer interface (ASCII or EBCDIC) which includes GP/L syntax processing.
- A Diskette Operating System (DOS) capable of meeting the CBEM delivery requirements of stand-alone and distributed CAI systems.
- A GP/L processor interface to support the implementation of other microprocessor-based languages (e.g., MUMPS).
- A Download/Upload subsystem for the transfer of programs or graphics data to or from a remote computer system.
- A self-contained set of development tools for the creation, updating, and viewing of locally designed CAI programs and graphics data.
- Two classes of locally stored graphics images, (1) DOS based graphics frames for archival storage and, (2) frame buffer memory for interactive and repetitive display of DOS images.
- Locally applied transformations to frame buffer.
- A modular hardware/software design, which facilitates field upgrades and future system expansion; e.g., an arithmetic processing unit, DOS memory, and communications modules can be added as required to the existing system.

C. Development Status

There are two PTS terminals under development. The first is a breadboard unit made up of commercially available hardware with special interfaces designed to allow inter-processor communications. The breadboard is primarily a laboratory unit designed to support the software development effort. It is available for demonstration of PTS capabilities. The second is the pre-production unit, which is presently being built. The major differences between the two units are appearance, expansion capability, and DOS performance. The pre-production unit will be available in March 1978 for initial testing. Estimated cost of a pre-production terminal is:

Basic ASCII Terminal	$7200.00	(includes touch panel)
Diskette System (500k byte storage)	1200.00	(optional)
PLATO option (keyboard & modem)	500.00	
16k byte buffer memory	500.00	(for either processor)
PILOT Interpreter	300.00	(requires Diskette)
Desk enclosure	500.00	(optional)

It should be noted that these prices are estimates and are not actual quotes. Also, the present availability of plasma panels in the U.S. may impact future terminal costs. As multiple orders are placed, these costs will in all likelihood drop. A final note, the PTS design does not require the plasma panel; if a CRT output devices is desirable, a conversion could be performed at a reasonable cost on a multi-terminal buy.

II Network Implications

A. Present Alternatives

A spectrum of computer systems exist for the delivery of CBEM. These include network utilities, large scale computer-based systems, minicomputer-based systems, microprocessor-based systems, and stand-alone intelligent terminal systems. For purposes of clarity, let us consider just the two poles: network access and stand-alone intelligent terminals. Network access to a central utility provides the following three potential (theoretical) advantages:

1. access to the largest catalog of CBEM
2. access to the latest updates or revisions of CBEM
3. large scale aggregation of user statistics and comments

Existing network hosts are very emphatic on the need for user feedback to correct, improve, and maintain currency of lesson material. Hence, the importance of item 3 above.

Disadvantages of network access for the user are primarily economic and include:

1. cost of host computer usage
   (connect time plus CPU charges)

2. cost of communications
   (connect time plus characters-transmitted charge)

In network environments, "think time" on the part of the student can be very costly.

Stand-alone, intelligent terminal systems, on the other hand, offer major economic advantages insofar as, after the initial investment, no further charges are incurred by either student usage or "think time" (including coffee breaks). CBEM is available, in these stand-alone systems, via inexpensive storage media such as simple audio cassettes, or floppy disks. The disadvantages are:

1. limited material - only that on hand

2. lack of current revisions or updates

3. no large scale aggregation of student responses;

just the converse of the advantages to be derived from network access. The advantages and disadvantages of both alternatives are summarized in Figure 3.

B. Future Scenario

As seen in Figure 3, the advantages and disadvantages of network and stand-alone intelligent terminal delivery systems are mutually complementary. A recognition of this leads us to explore the possibility of combining both methodologies so as to maximize the advantages, and minimize the disadvantages. The following scenario is suggested:

1. A "master" catalog of CBEM is maintained in a network accessible environment. That is, a user may access the appropriate network host to use the material if desirable. The "master" catalog also maintains, with each lesson unit, the date of last revision.

2. A user (faculty member, librarian, or student), with a stand-alone intelligent terminal periodically accesses the "master" catalog on the network. If a desired lesson unit appears in the "master" catalog which is either not available locally, or is available but not current, the user initiates an action to "download" the program from the network host to the local storage medium on the intelligent terminal. A charge is incurred for each lesson downloaded in this fashion.

3. After completing step 2 above, the user disconnects from the network before, locally, utilizing the lesson units.

4. If the user (or organization) periodically dials back the network host, and "uploads" the student responses in order to aggregate student feedback, then a rebate will be given on the original charge for "downloading."

This scenario obviously combines the "best of two worlds." It provides the advantages of network access summarized in Figure 3, while, at the same time, minimizing the costs. LHNCBC's efforts directed at demonstrating the feasibility of the above approach is discussed in the next section.

C. Impact of PTS and Related Efforts on Medical Networks

Present implications of the PTS for network access to health sciences CBEM include:

1. need for only one terminal to access PLATO and other ASCII network nodes

2. reduction of host computer and communications costs through local processing

3. potential realization of scenario described in Section B.

Points 1 and 2 are readily apparent. The following discussion expands on point 3 above.

The basic requirements of the scenario in the previous section is an *integrated system* supporting "downloading" of lessons and "uploading" of student responses between stand-alone intelligent terminals and a host computer. It should be apparent, that the PTS has been designed with this function in mind. The PTS, itself, however, is just one part of an integrated capability under development at LHNCBC.

Complementary to the PTS, is the development of an integrated, multi-user CAI system/language (LHC-PILOT) (14,15,16) that is compatible across a whole family of computers (Data General) from the largest (ECLIPSE) to the smallest (Micro NOVA microcomputer). LHC-PILOT will also be implemented on PTS.

The LHC-PILOT system, with PTS as an integral part, is intended to demonstrate the smooth interchange of programs, data and control information in a hierarchy of processors. The LHC-PILOT system is presently under test and evaluation. Network scenarios, such as those outline above, are being developed and evaluated. The capability to "shift the load" within a CAI system provides LHNCBC designers a development tool for optimizing the network/stand-alone scenarios. Through analysis of these scenarios LHNCBC can develop recommendations for future distributed CAI system implementations. The future of distributed processing, in CAI systems, clearly rests on the ability of the system designers to distribute the computational load, in a hierarchy of processors, each optimized for its function within the overall system. The LHC-PILOT and PTS development efforts are two of LHNCBC's projects directed at demonstrating high-performance, low-cost distributed CAI delivery systems with high potential impact for medical networks.

CONCLUSIONS

The PTS described herein will allow the utilization of sophisticated computer-generated graphics with all CAI languages of interest to the health sciences community. This includes the stand-alone development and delivery of CBEM in PILOT as well as other microprocessor based languages. Every effort has been made to provide for maximum flexibility and modularity at a reasonable cost. It is expected that future improvements in the technology and an increased demand for the capabilities demonstrated in this system will serve to reduce costs even further.

The flexibility of the PTS should also allow more institutions to explore the utilization of existing CBEM without fear of early obsolescence.

ACKNOWLEDGEMENTS

Mr. Jack Stifle, University of Illinois for providing a behind-the-scenes view of the PLATO system, present and future. Mr. Stifle's support in insuring PLATO V compatibility was critical to the PTS development.

Mr. Steve Bruckner and Ms. Adrienne Kleiboemer of Mitre Corporation and Mr. Glen Chapman of Boeing Computer Services for their technical support during the PTS development. The development schedule could not have been met without their efforts.

REFERENCES

1. Smith, Stanley G. , and Sherwood, Bruce Arne,. "Educational Uses of the PLATO Computer System" Science p. 344 - 352, Vol. 192., April, 1976.
2. Coursewriter is an IBM product. Refer to IBM for latest manual and documentation.
3. Zimmerman, Joan, "Book of MUMPS", MUMPS Users Group, 700 South Euclid Avenue, St. Louis, Missouri 63110, U.S.A., 1977.
4. "Medical Education Programs, User's Manual." Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts.
5. Starkweather, John A., "Making Computers Easier to Use Through: Distributed Mini/Microprocessors: PILOT" in Proceedings of the COMPCON Fall 75 Conference, p. 185 - 188, 1975, IEEE Catalog No. 75 CH0988-6C.
6. Starkweather, John A., "Guide to 8080 PILOT, Version 1.1", Lister Hill National Center for Biomedical Communication Internal Report. Also, NTIS PB-270 715/6WC.
7. Stifle, Jack, "A Plasma Display Terminal" Cerl Report X-15, University of Illinois, March 1971.
8. Stifle, Jack, "A Glimpse of the PLATO V Terminal", In New Directions in Educational Computing: Proceedings/1977 ADCIS Winter Conference, Wilmington, Delaware, p. 186-191.
9. Bruckner, S. and Carson,J., "Graphics Capabilities of the PLATO System", Mitre Report MTR-7560, June 1977.
10. Johnson, S.L., Walters, R.F., "Microprocessors and MUMPS: Implementations and Applications", Proceedings of the 1977 MUMPS User's Group Meeting, published by MUMPS User's Group, St. Louis, 1977.
11. Ford, William H. Jr., "Interactive Graphics System Under MUMPS", Proceedings of the 1977 MUMPS User's Group Meeting, published by MUMPS User's Group, St. Louis, 1977.

12. Newman, W.M., Sproull, R.F., "Principles of Interactive Computer Graphics", published byMcGraw-Hill, New York, 1973.

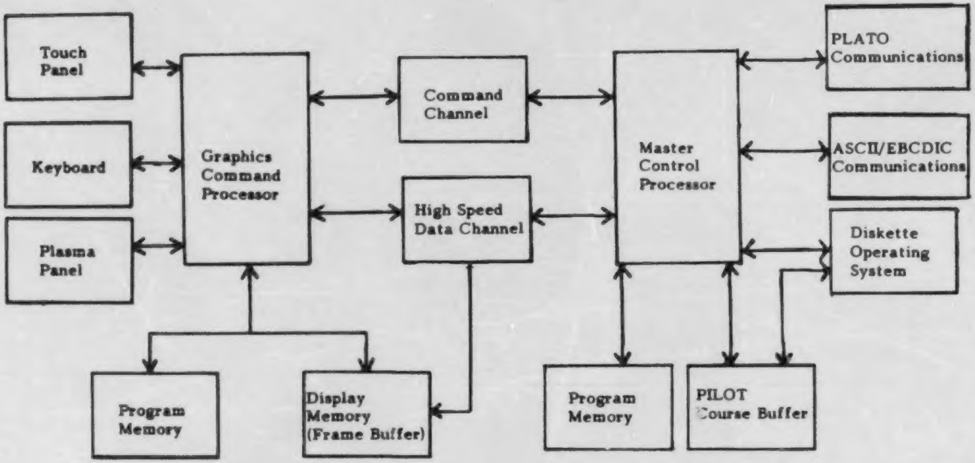
13. COMTRE Corporation, "Multiprocessors and Parallel Processing", published by John Wiley and Sons, New York, 1974.

14. Lister Hill National Center for Biomedical Communications, PILOT Users Manual, Internal LHNCBC Document.

15. Lister Hill National Center for Biomedical Communications, PILOT System Logic Manual, Internal LHNCBC Document.

16. Lister Hill National Center for Biomedical Communications, PILOT System Managers Guide, Internal LHNCBC Document.

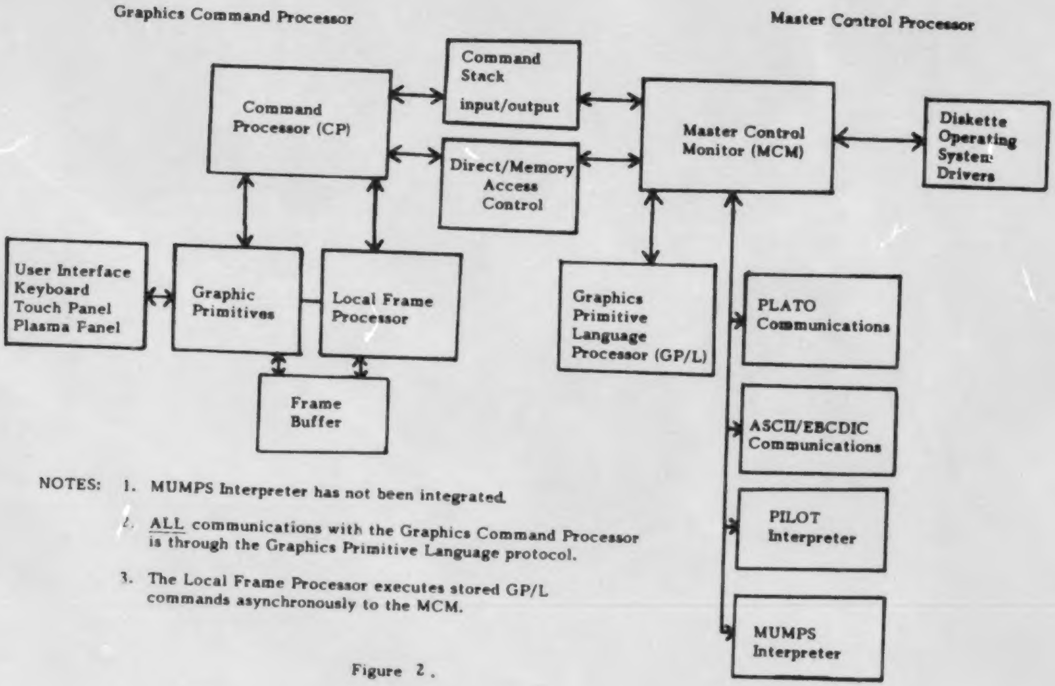
Overview of Plasma Terminal System Hardware


Touch Panel
Keyboard
Plasma Panel
Graphics Command Processor
Command Channel
High Speed Data Channel
Master Control Processor
PLATO Communications
ASCII/EBCDIC Communications
Diskette Operating System
Program Memory
Display Memory (Frame Buffer)
Program Memory
PILOT Course Buffer

NOTES:
1. Both processors use direct memory access channels for high volume data transfer.
2. ALL devices/processors excluding the Plasma Panel, are interrupt driven.
3. Total memory (program and buffers) cannot exceed 64K bytes in either processor.
4. Future expansion includes a Math Processing Unit for either processor.

Figure 1.

Overview of Plasma Terminal System Software


Graphics Command Processor
Master Control Processor
Command Stack input/output
Command Processor (CP)
Direct/Memory Access Control
Master Control Monitor (MCM)
Diskette Operating System Drivers
User Interface Keyboard Touch Panel Plasma Panel
Graphic Primitives
Local Frame Processor
Graphics Primitive Language Processor (GP/L)
PLATO Communications
Frame Buffer
ASCII/EBCDIC Communications
PILOT Interpreter
MUMPS Interpreter

NOTES:

1. MUMPS Interpreter has not been integrated.
2. ALL communications with the Graphics Command Processor is through the Graphics Primitive Language protocol.
3. The Local Frame Processor executes stored GP/L commands asynchronously to the MCM.

Figure 2.

	Network Access	Stand-Alone Intelligent Terminal Systems
number of available lessons	maximum	limited to those on hand
updates & revisions	current	not current
aggregation of feedback	maximum	minimum
host computer costs	yes	no
communication costs	yes	no

(unshaded areas represent relative advantages, and vice versa)

Figure 3 - SUMMARY OF ADVANTAGES & DISADVANTAGES

ADCIS ABSTRACT

MOLARS - A DENTAL SCHOOL COMPUTER BASED CLINICAL EDUCATION SYSTEM

I. Intended Audience

This presentation is intended for those involved with designing and implementing computer systems to aid in the education and administration of both dental and patient care systems.

II. Purpose

With the field of dentistry and medicine, in general, expanding at such a rapid rate, there is a significant need to expose students to as wide a spectrum of clinical experience as possible.

Coupled with this requirement is the need to provide a comprehensive patient record system. It is this combination of both an educational and patient care record system which is required to serve the needs of the dental students.

It was felt that the system should be constructed in such a manner as to simulate, where possible, the actual practice of dentistry. In this way, experience gained in interfacing with the system would tend to reinforce good record keeping procedures during actual dental practice.

The MOLARS system conforms and reinforces this desired dualistic structure. The structure of the system itself, along with the rationale concerned with the design process will be discussed in detail.

III. Method

The presentation will be done in a top-down manner, discussing the structure of the Dental School, the nature of clinical experience and its relationship to the design of MOLARS.

The structure of the MOLARS database (implemented on an IBM 370/145 under OS/VS1 with IMS) and its relationship of the functional modules to patient registration, screening and student assignment will be presented from the "patient life cycle" perspective.

Each functional module (written in PL/I) will be discussed both from its contribution to patient care and to its contribution to student education.

This flexibility of the system, because it is table driven, along with its relationship to American Dental Association standards for patient care, will also be presented.

IV. Conclusion

MOLARS represents a comprehensive solution for both the education of dental students and patient care for a dental school.

COMPUTER-ASSISTED INSTRUCTION IN MEDICINE: A GERMAN VIEW

Gunnar Voss, Jörg Weidenhammer, Hans E. Renschler

ABSTRACT - Some 20 American programs of Computer-Assisted Instruction in Medicine have been implemented at the University of Bonn, showing the problem of portability to be soluble. For a short time the Health Education Network was used, too. Seven programs were evaluated by the means of questionnaire or personal interview. The results clearly indicate that students feel comfortable working with programs of the tutorial mode and that they regard them as being motivating and more efficient than traditional instruction. Furthermore there was a very favorable response to clinical simulation programs.

1. INTRODUCTION

There have been two phases in the project to be reported here. During the first we studied the relevant literature (Weidenhammer 1976), established contact with many CAI groups in Canada and USA, and went on an intensive information collecting tour of some 20 of these CAI centers, to find out the current state of the art in Computer-Assisted Instruction in Medicine. The reason for having a relatively long phase of preparation was the very much delayed delivery of our hardware. When the terminals finally arrived there was less than one year left for implementing programs and gaining experience concerning their usefulness. This time was far too short for writing a number of programs as well as testing their instructional suitability. We are very grateful and indebted to the American CAI people, who gave us their programs and who, by their willing cooperation, enabled us to implement some 20 courses on the IBM 370/168 of our University Computer Center.

We had one typewriter, 3 CRT's, and one printer at our disposal, all supplied by IBM. We used standard FORTRAN IV and PL/1 of our Computer Center. In the FORTRAN language we implemented the physiological models MACMAN, MACPUF, MACPEE, and MACDOPE of the McMaster University, Hamilton, and a FORTRAN version of the Massachusetts General Hospital's (MGH) Cardiopulmonary Resuscitation Course also prepared at McMaster. In addition the access of other MGH programs was possible over the Health Education Network. For the cardiology course CARDI we implemented the language PILOT 73. To be able to use programs like OPHTHA, FUNDUS, and CASE we implemented Coursewriter III, where we had to expend a lot of time adapting it to our terminal configuration. - Seven of the programs used we tried to evaluate. These programs and our experiences with them will be described in the next sections.

Mr. Voss now is a member of the Project Group Computer Assisted Training (CAT) at the Fachhochschule für Technik , Esslingen; Mr. Weidenhammer is currently on his internship at the Marienhospital Euskirchen; Professor Renschler is Director of the Institut für Didaktik der Medizin der Universität Bonn. - This study was supported by the German Federal Department of Research and Technology.

2. THE SEVEN RATED PROGRAMS

As our contacts with the Clinic of Ophthalmiatrics were so good and because we found much interest and a highly cooperative attitude on the part of the Institute for Experimental Ophthalmiatrics we started our CAI venture with OPHTHA and FUNDUS. These Coursewriter III programs of the tutorial mode we receiven from the Ohio State University. Ophtha is accompanied by 37 and Fundus by 108 diapositives. Fundus has a simple question format. In the main part to each question there is only one right and one wrong answer. In the concluding section 26 slides showing different eyegrounds are displayed again and the student has to enter in natural language what is shown. Ophtha has a more varied question format: right/wrong, multiple-choice, matching items, open questions to be answered in natural language. The Ophtha diapositives are not of the best quality, while Fundus uses extremely good ones.

The programs teach the fundamentals one has to know to give a correct interpretation while examining the fundus of the eye. With the application of these programs we had a specific hypothesis in mind with respect to their possible instructional function. We knew that many students find it difficult to interpret what they see using the ophthalmoscope, because they lack the relevant knowledge to be able to correctly assess observations of the eyeground. We felt that the CAI courses would be helpful in meeting this need. In this way students should later be in a better position, in their bed-side-teaching to assess their observations.

Much work was put into the adaptation of 4 lessons of Dr. R.E. Rossall's Coursewriter II Cardiology Program, developed at the University of Alberta, Edmonton. This work was done by our colleague Dr. G. Schilling, who named his version CARDI. CARDI presents via three media (CRT, slide projector, tape recorder) information on the clinical alterations of Mitral and Aortic Stenosis as well as Mitral and Aortic Incompetence. While in the original program (implemented on a IBM 15oo) the audio and the visual information is controlled by the CPU, our students had to operate the slide projector and the tape recorder on their own, because we did not succeed in constructing the needed interface on the hardware level. As we were unable to use Coursewriter II (there are no IBM 15oo computers in Germany) we had to rewrite the program, for which we took the language PILOT 73, which we received from Starkweather and Kamp.

All this adaptation took us about 100 hours working time for one hour user time (the students on average needed 6 hours for all 4 lessons). In addition the course was pretested with 49 students and revised thereafter. The figure of 100 hours working time is in line with the amount of time needed by Dr. d'Ivernois of the University Laval, Quebec, who also adapted this course. According to him about 50 % of working time is saved by adapting a course instead of constructing a new one.

From McMaster University we received a FORTRAN version of CARDIOPULMONARY RESUSCITATION, a program developed by Massachusetts General Hospital. The program simulates patients with cardiac arrest - the version used by us included 7 cases - and takes the student through the sequence of cardiopulmonary resuscitation techniques. All this is done in a step-wise fashion taking advantage of the simple multiple-choice format. At each step the patient's reaction is described and the student has to make a decision about what to do next. Then the patient again reacts to the measure taken and the student has to choose his next decision.

Other MGH programs, mainly ABDOMINAL PAIN and COMA, we used over the Health Education Network. For this purpose we had to rent a Silent 700 terminal with an acoustic coupler. Our entry point to TYMNET was Brussels.

COMA is designed to teach how to evaluate a comatose patient as such patients present to the emergency department. Thirtyeight causes of coma are considered, including both primary neurologic disorders and toxic-metabolic conditions.

After being given a brief initial history, the student must evaluate the "patient" by asking for further history, physical findings and laboratory test data, using numbers from the accompanying vocabulary. This can be done in any sequence, though the computer will refuse requests that are not reasonable. The answers to history and physical exam items will be given immediately, while the results of laboratory tests will be given after a time delay reflecting the real world time required for the test. If the student is unable to proceed without one or more test results, he may push the computer's clock forward by typing "Time" in order to receive these results at once. A variety of assistance is available, if one types the word "HELP". The student may review the data gathered, find a test's normal value, get information about any item in the vocabulary, our get advice on how to further work up the "patient".

In ABDOMINAL PAIN the student is given a short description of a patient with a chief complaint of abdominal pain. The patient may have any one of 33 different causes of acute abdominal pain. Again the student has available an index of history, physical exam and laboratory data items about which he can obtain information.

At any time, the student may type the word "HELP" to request the computer to interpret information gathered to that point, criticize the student's last action, and suggest the most useful tests to perform next. At any time, too, the student may decide that he has sufficient information to terminate the dialogue and make a final diagnosis. In entering his diagnosis, the student types the name of the disease rather than a number from a vocabulary list. There is a powerful free text recognition program which allows the computer to recognize almost any plausible diagnostic term that is chosen by the student.

We also implemented the very well known CASE system (Computer Aided Simulation of the clinical Encounter) developed at the University of Illinois. The special thing about this Coursewriter III program is a dialogue pattern that from beginning to the end is in natural language. The student again is asked to take a history and to get the relevant physical exam an laboratory data. When he has completed the dialogue he receives a description of the diagnosis and a sample treatment plan suggested by the author of the case, as well as a list of the critical concepts which the author considered important in identifying and managing this particular disease situation. With each critical concept there is an indication wether the student asked for this information.

As German interns are not perfectly fluent in English Medical Terminology, we prepared a glossary of important terms which they were allowed to use during their interaction with the simulation. For the purpose of evaluation we have used the cases John Franklin, Esther McGrory, James Bond, Richard Lemis, Bonnie Clyde, George Thompson, Horst Schultz and Nicole Laurens. After working through some of these cases there was a structured group discussion of three interns at a time.

The students who have seen the courses OPHTHA, ABDOMINAL PAIN, and COMA were interviewed while those taking FUNDUS, CARDIOPULMONARY RESUSCITATION, and CARDI answered a questionnaire. The items used for the CARDI questionnaire were adapted from the Student Opinion Survey (SOS) by kind permission of the Computer Assisted Instruction Laboratory of the Pennsylvania State University. This allowed us to compare the reaction shown by American and by German students to CAI.

3. FINDINGS

60 students in their second clinical year used the tutorial programs OPHTHA or FUNDUS in conection with heir regular instruction (lecture and bed-side-teaching) in Ophthalmiatrics. Participation took place on a voluntary basis. The programs used were in English language.

The average time spent on FUNDUS was 3 hours and 55 minutes, most students choosing 2 to 3 sessions. The average time spent on OPHTHA was only one and a half hours, because most students chose a shortened version we had specifically prepared for this purpose. The students taking OPHTHA were interviewed while students who had used FUNDUS answered a questionnaire.

The rating of the effectiveness of these courses was positive, since half of the students believe that they learn more using the computer than studying a good textbook and 85 % regard this method of instruction to be more efficient than the usual lecture. This does not mean that they want to abolish the lecture completely. Some students like the personal way of teaching; they feel it to be more vivid; they appreciate the opportunity to ask questions and the social atmosphere as a whole. What students want is fewer and better lectures combined with more bed-side-teaching. And as a third component they would like computer programs, for two thirds are clearly convinced that the inclusion of CAI would improve teaching in Ophthalmiatrics, and the other third thinks it is possibly good. Very favorable views were also expressed by four professors of Ophthalmiatrics, who thoroughly checked the two courses, which took them 2 to 3 hours for each program. If there should exist enough such programs - in the German language - they think that a combination of one fifth CAI, two fifths lectures, and two fifths bed-side-teaching would be a good mixture.

Why do students like CAI? - The three main reported reasons are:

- In order to answer the questions you have to be active and you have to concentrate on the material shown.
- It is fun to have feedback to the answers given.
- You can work at your own pace; you may come and go when you like.

For which instructional goals are courses of this kind thought to be suitable?
The leading three alternatives have been (each chosen by some two thirds of the students):

- To get an overview and first impression, before one is going to have bed-side-teaching.
- To learn in more depth such subject matter one already is acquainted with.
- For self-evaluation purposes.

The first alternative concurs with a hypothesis we had before application of the programs (s. page 2).

53 students, most of them in their first clinical year, took, as a complement to a programmed course on heart auscultation, the multi-media cardiology course CARDI, where they spent on average 6 hours on the 4 adapted CAI lessons. Again the rating of the effectiveness of the tutorial CAI mode was positive:

86 % were satisfied with what they learned while taking the course.
82 % feel that CAI, as used in this course, is an efficient use of the student's time.
75 % think that CAI makes it possible to learn quickly.
73 % believe that, in view of the amount they learned, this method seems superior to traditional instruction.

One of the most important parts of the tutorial interaction process is the adequacy of feedback responses the student receives to each answer he enters. With respect to this feature the cardiology course seems to be of good quality, since 82 % judge the responses to their answers to be adequate. And there is a large majority saying that the encouragement from the feedback received is very helpful for their learning.

As the tutorial teaching mode is said to simulate the personal interaction between a tutor and a pupil, it is interesting to know, whether programs of this kind are in fact flexible enough to create such a personal atmosphere. Only 44 % of our students claim to feel as if they had a private tutor; the majority of 56 % does not perceive it this way. Also there is a significant group of 42 % that found the computer-based learning not to be flexible enough.

The limited flexibility, however, seems to be experienced as a minor disadvantage, because it wasn't found that the students felt uncomfortable about CAI. On the contrary, they did not feel frustrated by the learning situation (96 %); they did not find this way of learning to be too mechanical (79 %), and they did not expect material which is otherwise interesting to become boring presented by the computer (87 %).

That the course is motivating is shown by the following results: the students felt challenged to do their best work (83 %), the program has contributed to the development of positive attitudes towards the course material (74 %), and as a result of having studied by this method, the students are interested in learning more about the subject matter (91 %). - Finally a very important point is the fact that CAI allows the student to work at his own pace. All participants agree that this is a very favorable condition for learning.

Let us now turn to the clinical simulation programs beginning with CARDIOPULMONARY RESUSCITATION of the Massachusetts General Hospital, which we used in a version prepared at McMaster University. This course is constructed in the multiple-choice format and therefore akin to CAI of the tutorial type. 25 students, most of them in their second clinical year, and 10 interns, worked up 4.6 cases on average for which they needed 80 minutes. Again Computer-based Instruction is rated as an efficient use of students' time (90 % agree). Two thirds believe that you learn more by using the computer than by studying a good textbook. According to 80 % the subject matter is taught in a way that cannot be imitated by traditional methods, such as lecture and books.

Two thirds felt the program to be realistic and for this reason felt challenged to do their best. Half of the students during the program had the impression of being confronted with an authentic case. On the other hand, a fifth of those questioned found the CAI not to be flexible enough and another third felt uncertain on this point. One third also found the multiple-choice format restricting.

There was 90 % agreement that practical training combined with computer programs is more efficient in teaching resuscitation techniques than practical training by itself. When asked for the best combination of media in training resuscitation, practical exercises and computer programs were mentioned most often (by approx. 90 %). They were followed by textbook (60 %) and film (50 %). About a third also included lectures and last of all came the slide-tape show. The main reasons for prefering computer programs are the active involvement of the student, the immediate feedback, the use of the case method, and the enforced decision making reflecting the real world situation. And again it is seen as a very favorable condition that the student may work at his own pace.

Also six anesthesiologists have examined all cases of this program. Their opinions are similar to those of the students and interns. They also find the program realistic and extremely suitable for training purposes.

We now proceed to the other type of MGH clinical simulation program, where the patient is represented by a static model for which the computer has a file of information, which the student can get by using a vocabulary. 10 interns and 8 physicians used this type of program, mainly ABDOMINAL PAIN and COMA. Altogether they have worked up 57 cases of Abdominal Pain, 55 cases of Coma, and 22 cases of other programs (Diabetic Ketoacidosis, Hypertension Diagnosis, Jaundice, Joint Pain, Trauma). On the average the interns saw 9.3 cases, for which they needed 4 and a half hours, and the physicians have worked up 5.1 cases which took them 2 hours and 40 minutes on the average.

12 other interns used the CASE system. On an average 3.5 cases were seen by each intern - altogether 42 cases. It took 50 minutes to complete one case. By comparison, only 30 minutes were needed for one case of the MGH vocabulary type programs.

The 22 interns and 8 physicians who altogether saw 176 cases (COMA, ABDOMINAL PAIN, CASE) were asked to comment on 6 claims in favor of the use of computer simulated patients. There is perfect agreement on the two following claims and a little less agreement about the third one: (1) Experienced clinical teachers with sufficient time are rarely found. (2) Artificial patients can be represented completely (beginning with the first contact and continuing until final diagnosis and therapy decision). Several restrictions that characterize the real world situation do not apply, e.g. the clinical schedule, limited time for examination of the patient etc. (3) Contrary to the real world situation the student can make mistakes without taking risks and learn from these mistakes.

About the claim: "The students cannot be provided with exposture to all important clinical problems; computer programs can be constructed in an unlimited number and are available at any time", there is a basic agreement, but several times the point was made that the computer nevertheless has its limits: it's not possible to represent everything this way, e.g. dermatoses. The computer is not really adequate in delivering information that in real life is gotten by eye, ear, smell, and by palpation.

Feelings are mixed concerning the claim "Bed-side-teaching normally takes place in a more informal and not very systematic fashion. Computer programs allow the possibility of more systematicly training the diagnostic decision making". Half of those questioned do not agree with the first part of this claim. They think their bed-side-teaching is quite systematic, even if it varies from teacher to teacher. One intern also said that small group bed-side-teaching, as customary in England, clearly would be superior to computer programs, and that real patients could be asked in a more flexible way.

One of the six claims was unanimously rejected: "An instructor, especially a good one, can be too good a diagnostician. He is so quick in his decisions and takes into account such complex circumstances, that the student cannot follow". This does not seem to describe the typical situation in Germany. The clinical instructor usually presents patients whose case histories are known to him and so he can unfold the case from "inside". The students said that there were certainly those who were quick to diagnose, but who would modify their teaching methods to suit the needs of the students; if this were not the case, it would be up to the students to interrupt with questions.

The interns and physicians, who have worked through the Boston programs, have answered some additional questions. All believe that a student learns more using the computer than studying a good textbook. They give as the main reason that the book always begins with a description of the clinical problem. The symptoms and data follow later. In the programs as in real life it is the other way round: at first you get the data and from there you have to go on. This sequence is supposed to leave a deeper impression, to ask for more participation and above all it is analytical.

All are fully convinced that in order to teach diagnosis (and therapy) of outpatients and acute cases a combination of lecture, computer programs and practical exercises is more appropriate than lecture and practical exercises by themselves. It is true, however, that half of the physicians stress the fact that a good instructor - if available - is better than the best program. One M.D. suggests that success in practical training depends on the size of the group of the students. With a group of not more than six persons (as in England) computer programs could never compete with a good instructor who gives his attention to each one of his students. If there were an adequate number of clinical teachers and patients available, computer programs would be redundant. By contrast, under German conditions (the groups being large) a combination of teaching aids including computer programs would certainly be superior.

The next question was about how much time should be spent on clinical simulation programs during internship. To this question the following average figures were given:

- by the interns 5.3 hours per week
- by the doctors 4.5 hours per week.

To a similar question the CASE-group suggested 3.5 hours per week. These figures presuppose that the practical training is not reduced.

The interns feel that the appropriate stage for introducing these programs is the second clinical year. According to the physicians one should wait until the 3. clinical year and the program COMA, for example, they would even postpone until internship because of its difficulty. If there were several versions of the computer programs at different levels, they could be used in all phases of clinical education. In their present form the programs were also thought to be suitable for refresher courses in continuing medical education.

It is not intended that these programs should only be used as enrichment on a voluntary basis. The interns feel they could very well be an integrated part of the curriculum. Of course, then there should be an explicit coordination with lectures and bed-side-teaching. The interns see the main benefit derived from this kind of learning in an improvement of their differential diagnostic abilities, something that is felt to be lacking in the present method of instruction. The physicians expect from clinical simulation programs that the diagnostic process will be carried out in a more conscious fashion and that the student will be taught a more methodical and economical diagnostic procedure.

4. COMMENT ON EVALUATION

As everyone having to do in some way with Educational Research certainly is aware there exists the very tricky problem of how to adequately evaluate instructional systems. What we have done in this respect is on a modest scale, of course. But we were forced to continually reassess this problem. Therefore we feel this deserves some mention here.

We had promised to the federal institution, from which we received the grant, that we would do experimental evaluation studies, and provided there had been sufficient time, those studies would have been carried out. However, while visiting CAI groups in the United States we also met colleagues of the well-known Center for Instructional Research and Curriculum Evaluation at the University of Illinois, Urbana-Champaign, who warned us against doing such simple outcome studies and instead, suggested investigating how students perceive CAI. One problem, they argued, is that as CAI allows the students to work at their own pace the better students will proceed faster; in traditional lecturing this does not apply and therefore on the average the CAI group has the chance to learn more effectively. As our reported results show very clearly that one of the main advantages of CAI as seen by the students is, indeed, the opportunity to learn at one's own pace, we can only agree to the possible importance of this argument.

At any rate we very early gave up the idea of comparing CAI with lectures, because normally in studies of this kind at least two difficulties are involved. In the first place, the investigator is dependent on the teaching ability of the chosen lecturer and, secondly, it is difficult to insure that exactly the same subject matter is treated. That this insufficient control, in fact, may be the reason for invalidating experimental results, we learned for instance at the Institute of Cardiology of the University Laval, Quebec, where a significant difference between lecturing and the CAI Cardiology Course was found (d'Ivernois et al., 1975).

We ourselves therefore would have preferred to produce a completely congruent audiovisual version and to experimentally compare it with the CAI Cardiology Course (we began to do so but because of insufficient time were not able to complete it). Against this type of study, however, the argument still applies, that it is impossible to prove the general superiority of anyone medium by just comparing single courses only, for there might be simply a difference in quality between the programs one has chosen. If one is unable to do many experiments to check a whole range of different course materials, it is possibly preferable to follow the suggestion of the instructional researchers of the University of Illinois, in other words to merely assess how students perceive the characteristics of CAI, as we in the end did.

Admittedly one disadvantage of the design chosen for our study is that there are no precise rules for generalizing the results obtained. Even assuming that our findings were based on representative samples, what would such findings as that our students claim to experience CAI as motivating and as more efficient than traditional teaching actually mean? Is it mere novelty (Hawthorne effect)? Does CAI just stand out compared to an otherwise low standard of teaching? What part of the effect is due to the good quality of the slides accompanying the CAI course or other peripheral features? Without experimental control there is necessarily a great scope for ambiguity. - On the other hand, there is one favorable indication speaking for the validity of our findings. Our using an American Opinion Survey made it possible to compare the reactions of German and American students working with CAI courses of the multimedia tutorial mode, where only the course material differed. Among 18 items that could be compared there was only one showing a difference in attitude, while the responses given to all other items were very similar (Schilling & Voss, 1977). This seems to indicate that our findings might be quite substantial instead of being rather ambiguous.

5. CONCLUSIONS

CAI programs of the tutorial mode seem to be characterized by a combination of such distinctive advantages that even the problem of insufficient flexibility does not bother the students. The main advantages are that the student is actively involved in the learning process, that he is encouraged by immediate feedback, and that he is allowed to work at his own pace.

Clinical simulation programs are also seen as superior to traditional teaching methods, which is not so surprising as they are, in fact, a medium with which no other medium can compete. The only possible competitor for systematic training in clinical problem solving would be the experienced clinical teacher in the small group situation. Unfortunately such teachers, that is those, who have sufficient time, are rarely to be found, if not nonexistent. But even if we had them, it might very well be that programs of this kind could contribute specific aspects of their own towards building up an economic and efficient diagnostic decision making. Consequently it would seem that a well balanced mixture of lecture, bed-side-teaching and simulation programs (the latter for about 4 to 5 hours per week, as the persons questioned suggested) would be an ideal combination.

If there are by far too few teachers, as in Germany, there exists the danger of conceiving of computer "patients" as viable substitutes for bed-side-teaching. This certainly would not be approved by our interns and students.

REFERENCES

d'Ivernois, J.F., J. Baspeyre, and Y. Marquis: Enseignement de la Cardiologie par Ordinateur: Bilan d'une Expèrience. L'Union Mèdical du Canada, April 1975. - Schilling, G., and G. Voss: Diagnostik erworbener Herzfehler - Übertragung und Erprobung eines kanadischen Lehrprogrammes. Part of the Final Project Report, Bonn, 1977. - Weidenhammer J.: Computerunterstützung der medizinischen Ausbildung. Literaturauswertung zum Computerunterstützten Unterricht in der klinischen Ausbildung in den U.S.A. aus den Jahren 1963 - 1975. Bonn, 1976.

DDS: THE DENTAL DIAGNOSTIC SIMULATION SYSTEM

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Introduction

Accurate diagnoses of pathological conditions may be considered the essence of the contribution health professionals provide to society. The obvious application of this process is the subsequent treatment of these conditions. In this sense, dental education, as with education in the other health sciences, should concern itself, in a high priority manner, with instruction of its students in both the process of diagnosis in general and the substance of particular diagnoses with regard to specific cases. Despite the fact that such instruction is of utmost priority, in practice only relatively limited amounts of diagnostic experience may be gained in typical dental education programs. A number of reasons contribute to this situation. Harless, et al. (1971) and Christopher and Wilson (1975), have identified many of these. One of the primary reasons, however, is simply the fact that students in dental school are subject to the "luck of the draw" in most instances as far as which patients will be assigned to them. Although serving a necessary function, this is not an ideal situation and does not necessarily allow for a wide variety of good instructional cases upon which to broaden the students' diagnostic abilities.

A computer-based case simulation system is a viable attempt at a solution to this problem. In such a system, prime instructional cases may be developed by faculty and then experienced by all students in a deliberate fashion, not only by those who, by chance, would have been assigned patients with such maladies. Certain schools of medicine and veterinary medicine have developed such systems to present instructionally significant case studies to their respective students (Harless, et al. 1971; Christopher and Wilson, 1975). Although dentistry has also joined in the attempt to solve the problem by producing certain computer-based simulated diagnostic materials (e.g., Cassidy, et al., 1972; Mullaney, et al., 1973), these have been somewhat speciality specific or, at least, single case specific. That is, these simulations typically represent diagnostic case studies of relatively limited scope for specific instructional application. If additional simulated cases are desired regardless of speciality area, in effect new course material must be written, coded for computer presentation, and then input into the computer system. DDS, the Dental Diagnostic Simulation System, provides an alternative to systems such as these in the sense that it may be used to generate simulated case studies in all of the dental specialty areas with case materials progressing through the gamut of the diagnostic process.

The development of DDS was founded upon four general objectives. The first was to develop a computer-based dental diagnostic system that would be applicable to all specialities of dentistry and which would allow the student the opportunity to experience the diagnostic process in a structured, yet self-controlled fashion for the most part. Secondly, because of the problems of faculty time and long-term motivation, it was an objective to develop a system which would require a minimum of effort by an author to produce a basic, diagnostic case study. By "basic" is meant a computer-based program which would represent the fundamental structure or skeleton of a simulated case, yet one which would be both entirely functional and instructionally valuable to the student. Thirdly, it was a purpose to establish a system that had a basic structure, as has been indicated, but was flexible enough to allow for the varied interests and emphases of case authors, and for the distinctive instructional properties of each case. And lastly, it was the objective to produce a system which would require minimal programming effort by the CAI sraff to generate the code necessary to operationalize a case. The rationale for this objective rests simply in the fact that the School maintains a small CAI staff.

DDS was developed for use on an IBM 370/115-2 computer system and was written primarily in the Coursewriter III, Version 3 interactive language for delivery on IBM 3277 display stations. In addition, two system functions were written in assembler language and are called into use through Coursewriter III capabilities. These system functions serve the purpose of storing and retrieving a multitude of information about each case which would not be possible under the limited direct storage facilities (i.e., counters, switches, etc.) of the Coursewriter III system.

Structure

Any case which has been generated by DDS exhibits two major areas of emphasis. The first is that given to the gathering of information aobut the "patient" and his/her dental problem(s) while the second is concerned with the student's submission of diagnoses pertinent to the case. Each of these general areas is subdivided into more specific units as follows:

Information Gathering

- History of Chief Complaint
- Personal Profile
- Extraoral Examination
- Intraoral Examination
- Medical/Dental History and Follow-Up
- Diagnostic Tests (e.g., percussion, microbiologic, etc.)

Diagnosis

- Psychological Evaluation
- Medical Conditions Regarding/Affecting Dental Management of Patient
- Home Care Evaluation
- Diagnosis of Oral Lesions/Conditions
- Periodontal Problems
- Diagnosis of General Conditions of the Teeth
- Diagnosis of Conditions/Lesions of the Jaws
- Diagnosis of Conditions Affecting Individual Teeth
- Diagnosis of Occlusion-Related Conditions
- Diagnosis of Ill-Defined Conditions/Diseases

Included in these various Information Gathering and Diagnosis units are approximately 700 distinct categories of information that may be requested or diagnoses that may be rendered. Student interaction with the system in supplying or retrieving particular pieces of information is accomplished in large part through coded numbers. These numbers and the information/diagnoses to which they correspond are contained in the DDS Console Booklet.

In general, case materials are organized and presented under the umbrella of a registered CAI "course". Within this "course", there exist the actual cases that would be available to the student. Materials for each of these cases are established primarily* through the use of course macros**.

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*Materials common to all cases and necessary for their execution are not generated by macros, but exist in a separate course and are copied into the "course" of cases. It is necessary that this copying process be done only once per such "course".

**A macro is a facility which will allow the generation of frequently used course statements. Each macro provides a different framework of statements that ultimately generates course materials, the particular nature of which may be tailored to a case by the specification of certain parameter values to be used by the respective macros.

The process described above results in a skeletal structure of a case, the exact nature of which will have been determined by information supplied by the case author and then used in conjunction with the macros. It should be emphasized that despite the fact that this produce represents only a skeletal framework of a case, it is entirely functional at this point without the necessity of any additional computer programming. Moreover, the generated product also includes limited feedback both about the desirability of information sought or tests requested, and the appropriateness of diagnoses made by the potential student user relative to the case in question. Each of the diagnosis units also furnishes an evaluation of student performance following its completion. If further interactions with the student are desired by the author, instructional "flesh" may be added to the existing structure using traditional CAI programming methods.

Even though DDS is considerably structured, there is a certain degree of flexibility afforded the author in developing a case using this system. A fundamental aspect of flexibility is provided by DDS simply by allowing both for a broad range of information that may be retrieved and a multitude of diagnoses, representing all dental specialty areas, that may be considered. Thus, authors are able to present case studies reflecting a wide variety of instructional emphases using a common mechanism. In addition, an author also has the option of excluding or by-passing any informational or diagnosis unit or, alternatively, simply providing a summary of information that would have been available from that unit. This is accomplished by not generating the macros in question or by generating only small portions of them. And, as before stated, supplemental instructional programming which is tailored to the particular character of a case is always a viable option.

In summary, the generation of a functional diagnostic case study by the DDS System requires relatively little effort both on the part of a case author and the CAI staff. As far as an author would be concerned, he need only supply the pertinent information relative to the units of the Information Gathering section and the correct, incorrect but plausible, and completely incorrect diagnoses for each of the units of the Diagnosis section in order to produce a basic case study. (This information, of course, is in addition to ancillary material regarding the case such as completed dental charts, pertinent X-rays, etc.) With this in hand, it is necessary only for a CAI staff member to convert these data into macro parameter values and subsequently generate the respective macros. To further ease this developmental process, author and programmer workbooks have been established.

REFERENCES

Cassidy, R.E., Marshall, F.J., Gaston, G.W., and Snodgrass, M.W. Computer assisted instruction for diagnostic problem solving of toothache. *Journal of Dental Education*, March, 1972, 36, 46-56.

Christopher, G.R. and Wilson III, G.P. A computerized approach to the teaching of the clinical problem solving process. *Biomedical Communications*, May, 1975, 3(3), 16-21, 31-33.

Harless, W.G., Drennon, G.C., Marxer, J.J., Root, J.A., and Miller, G.E. CASE: a computer-aided simulation of the clinical encounter. *Journal of Medical Education*, May, 1971, 46, 443-448.

Mullaney, T.P., Duell, R.C. and Smith, T.A. Slidetape and Computer-assisted instruction in endodontics problem solving. In T.A. Smith, S. Rovin, and E.W. Haley (Eds.), *Individualized Instruction in a Flexible Dental Curriculum*. San Francisco: U.S. Government Printing Office (DHEW), 1973.

The Effect of Mini/Micro Processors
on Computer Aided Learning Systems at the CSUC

ADCIS Convention March 1977

Interest Group Presentation

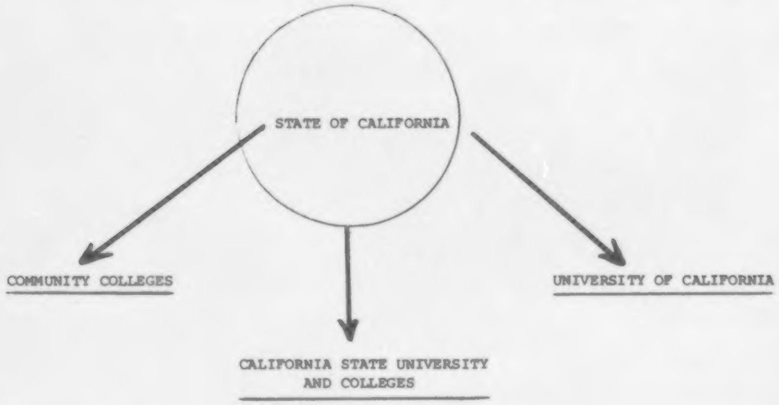
by

Laurel Lee Roberts, PhD

A topic of ongoing concern in several disciplines within the California State University and Colleges is how to take advantage of the boom in the Mini/Micro Systems and how to incorporate them into the educational process. Rather than imposing on any one campus, an already existing Computer-Aided Learning (C.A.L.) System, the mini/micro processor-based CAL systems allow the professors on any campus to experiment with CAL at an inexpensive price and provide them with the expertise needed to evaluate and appreciate the advantages of Maxi-systems. The software and courseware developed on the campuses of a big system such as The California State University and Colleges might then be the nucleus of a computer network to deliver cost-effective lessons to the students on all campuses. The purpose of this paper is to describe the methodology by which small CAL systems could be initiated on different campuses and then tied together to form a network.

I. INTRODUCTION

Higher education in the State of California, as illustrated in Figure 1, is divided into three components: the California Community College System with over one hundred colleges; the University of California with nine campuses; The California State University and Colleges composed of nineteen campuses. Each component serves a different


STATE OF CALIFORNIA
COMMUNITY COLLEGES
UNIVERSITY OF CALIFORNIA
CALIFORNIA STATE UNIVERSITY AND COLLEGES

TRIPARTATE - THREE SEGMENTS OF HIGHER
EDUCATION IN CALIFORNIA

FIGURE 1

segment of our population and functions based upon very different goals. The community colleges serve over a million students and operate on an open-door or low tuition policy for basically lower division students. Within these institutions, there tends to be a heavy emphasis on vocational education, community service, and the like. The function of the University of California, with its nine campuses, is based upon the goals of research, instruction, and service. The third segment of higher education is The California State University and Colleges, which has traditionally been a system of teaching institutions.

II. MICROPROCESSORS AND THE CALIFORNIA STATE UNIVERSITY AND COLLEGES

The governance of The California State University and Colleges includes the Governor of California, the California State Legislature, the Board of Trustees who are appointed by the governor for eight year terms, the Chancellor, and the nineteen campus presidents (Figure II).

Our northern most campus is Humboldt State University and our southern most institution is San Diego State University and its Imperial Valley Campus in Calexico on the Mexican border (Figure III). So we are talking about nineteen

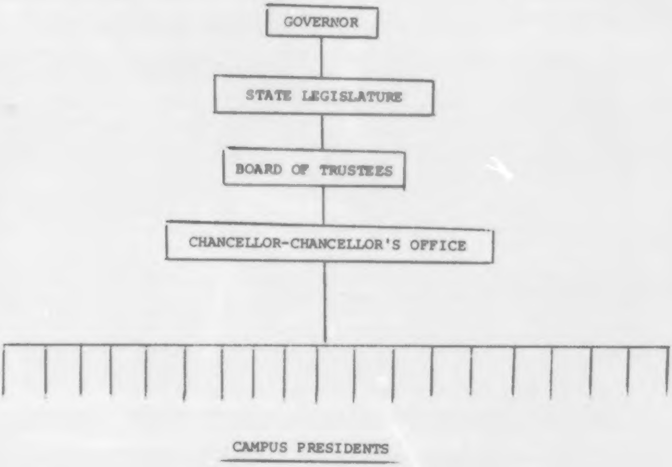
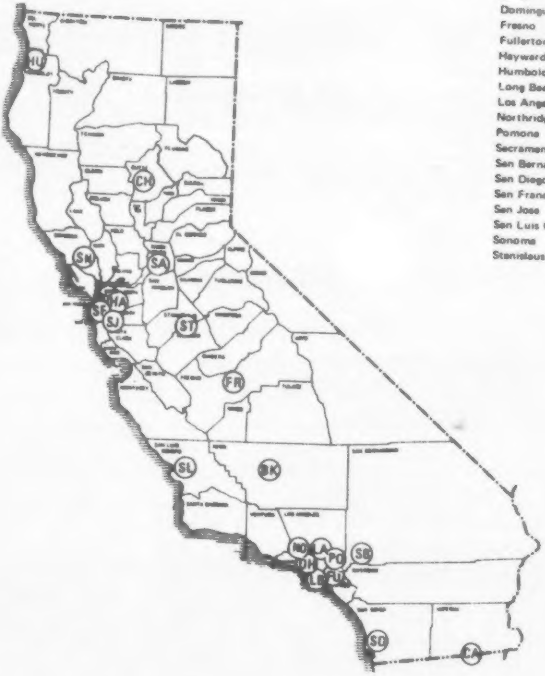

GOVERNOR
STATE LEGISLATURE
BOARD OF TRUSTEES
CHANCELLOR-CHANCELLOR'S OFFICE
CAMPUS PRESIDENTS

FIGURE II

THE CALIFORNIA STATE UNIVERSITY AND COLLEGES


HU
CH
SN
SA
HA
SF
SJ
ST
FR
SL
BK
NO
LA
SB
DH
PO
LB
FU
SD
CA

Library Name	Code
Bakersfield	BK
Calexico	CA
Chico	CH
Dominguez Hills	DH
Fresno	FR
Fullerton	FU
Hayward	HA
Humboldt	HU
Long Beach	LB
Los Angeles	LA
Northridge	NO
Pomona	PO
Sacramento	SA
San Bernardino	SB
San Diego	SD
San Francisco	SF
San Jose	SJ
San Luis Obispo	SL
Sonoma	SN
Stanislaus	ST

FIGURE III

campuses and three satellite learning centers covering approximately 1,000 miles, 17,000 faculty, and 312,000 students. With this in mind, it would be a gross understatement to suggest that the CSUC merely needs to explore the potentials of computer-assisted instruction and networking. Indeed, there is a critical need to share resources and to maintain the individuality of developments on each campus. While there is increasing pressure to more efficiently and effectively instruct greater numbers and diverse populations within existing resources, protecting campus autonomy is of the utmost important as well.

As a matter of fact, the systemwide administrative office of The California State University and Colleges is studying numerous communication networks. For example, we have a microwave television interconnection system between the California State University at Chico, the University of California, Davis, the California State University at Sacramento and several community colleges (Figure IV). We have a library network system utilizing United Parcel Service for interlibrary lending and borrowing among the nineteen campuses throughout the state. Operating in the Los Angeles Basin area is the CSUC Film Loan Network connecting five CSUC campuses in order to share instructional films, to avoid duplicate purchases, and to redirect film

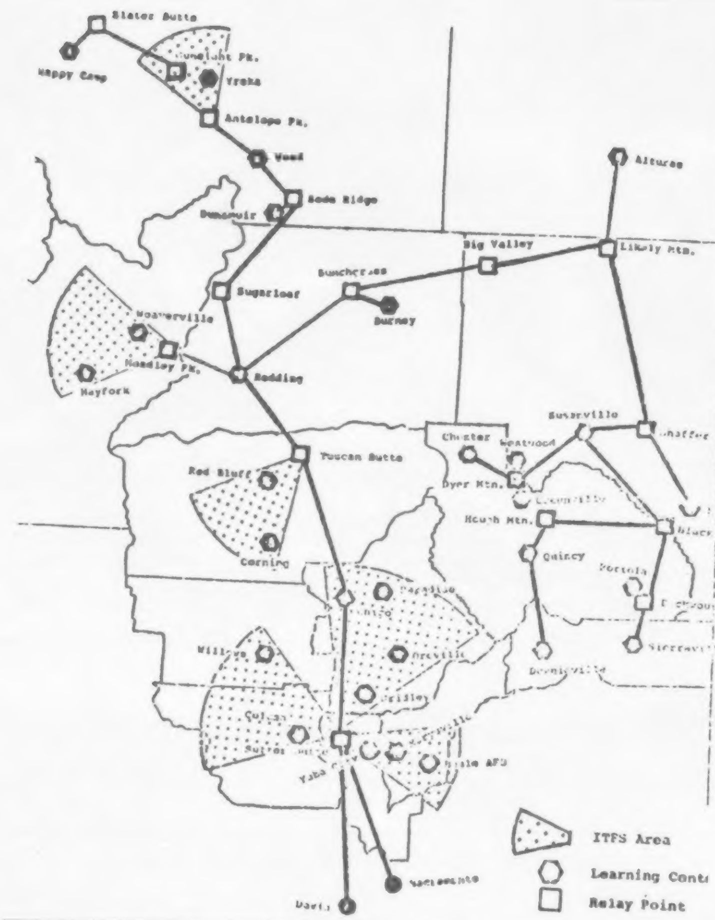

Slater Butte
Happy Camp
Gunsight Pk.
Yreka
Antelope Pk.
Weed
Soda Ridge
Dunsmuir
Alturas
Big Valley
Likely Mtn.
Bunchgrass
Sugarloaf
Burney
Weaverville
Hoadley Pk.
Hayfork
Redding
Susanville
haffer
Chester
Westwood
Tuscan Butte
Red Bluff
Dyer Mtn.
Greenville
Hough Mtn.
Black
Quincy
Corning
Portola
Paradise
Chico
Willows
Oroville
Downieville
Gridley
Colusa
Marysville
Sutter Butte
Yuba City
Beale AFB
Sacramento
Davis
ITFS Area
Learning Cent
Relay Point

FIGURE 4. TELEVISION DELIVERY SYSTEM
PRIMARY AND SECONDARY VIDEO
SYSTEM SHOWING ITFS LOCATIONS

rental fees into consortial funds; thus purchasing additional instructional materials for the five participating campuses. As an extension of this program, there are two other regional film exchange projects: one connecting two northern campuses; one connecting San Diego State with the Calexico campus. In other words, a systemwide network for film exchange is a clear possibility for the immediate future.

In addition, we are utilizing teleconferencing, fascimile transmission, and telephone lease lines. We are exploring satellite communication, rapid transmission and storage of information and we have begun work on a more encompassing telecommunication plan for the entire system. In dealing with such a hugh system like The California State University and Colleges, any means of increasing communication among the campuses becomes critical and the concept of networking becomes a necessity when dealing with budgetary constraints. Charged by the Master Plan of California Higher Education to be instructional institutions, The California State University and Colleges, as a system, needs to utilize computer-assisted instruction and CAI networking becomes a viable option for our consideration.

Within the CSUC, there are several PDP 11/45's that take care of all local timesharing applications. On some campuses, there are also some Data General NOVA's and the like. These minicomputer systems are used to produce and deliver computer-assisted instruction lessons. Our most active campuses involved in mini-CAI work are CSU, Fresno, the California Polytechnic State University at San Luis Obispo, and CSU, Northridge; however, there is considerable activity in this area at the California Polytechnic State University at Pomona, CSU, Fullerton, Humboldt State University, Sonoma State College, San Jose State University and to a limited degree, on most of the other campuses.

Currently, computer-assisted instruction within the CSUC is being done on a Digital Equipment Corporation (DEC) PDP 11/45 - a stand alone mini-timesharing computer. It includes a line printer for hardcopy reports as well as an on-line printer for each cluster of four CRT terminals. From about thirty-two ports available for each campus, roughly ten are connected to DEC Writers which produce hard copy output. The remaining ports are used with Teleray CRT terminals, augmented with audiovisual equipment.

The hardware supports the RSTS-11 Version 6B-02 System. In other words, there are many available languages in the system and most of them are used to develop computer-assisted instruction work.

At our CSU, Northridge campus, eight programs in English grammar and composition have been developed for use by students in the required elementary English course English 130. Up to 300 students have been working on those programs. Also, at that same institution, there has been tremendous response and success with simple interactive drill programs in Algebra, i.e. presentation, response, reinforcement. The range of disciplines involved in mini-CAI activity is very interesting. One of the programs at CSU, Fullerton, called MUSCLE, was written by a biology professor who wanted to provide his students with an exercise in naming and identifying the function of various muscles. Similarily, biologists at San Jose State University have become involved in CAI work.

At CSU, Chico, they have developed a program for teaching farmers how to plant and at Humboldt State University, modules have been written for students studying Genetics.

At the California Polytechnic State University at San Luis Obispo, several programs have been developed to teach BASIC and COBOL. Also, several programs in remedial spelling and arthmetic exist on the system. A language PILOT has been simulated on the system and several CAI programs have been initiated using PILOT as an authoring language.

Also, at Cal Poly, several microprocessors are used in the Electrical Engineering Department to enhance their teaching and laboratory work.

CSU, Fresno has done an interesting thing related to computer-assisted instruction. They have acquired seventy-five CAI programs from numerous sources such as Dartmouth, for campus use. In each case, two faculty members previewed and rated each program and those with the top ratings were rewritten to export to the CSU, Fresno system or to any system. Next, a handbook was generated, called the ABC's of CAI; thus indicating conferences in CAI, faculty throughout the state willing to help with CAI work, sources of course material and a listing of the 75 available programs, which includes a full page evaluative description. Their programs cross many disciplines: Biology, Psychology, Chemistry, Business, Math, Home Economics, Physics, foreign language and education. The amount of CAI activity on the Fresno campus suggests that mini-CAI work is a high priority item for the computer center staff. In fact, that campus anticipates undertaking a three-year project concerning the development of computer simulations to support instruction in the Social Sciences and to train faculty in the use of mini-computer simulations primarily in the fields of psychology, sociology and/or political science.

In essence, several computer-based mini-CAI programs are being developed, listed and used among our campuses. The goal ahead of us is to tie them all in a network without destroying the individuality of each campus; thus sharing resources while maintaining autonomy. A computer network has existed in CSUC since 1969. The system connects the campuses to CDC 3170 computers in the Division of Information Systems in the central office and in the Northridge Regional Center. The network is basically used for general purposes attempting to combine administrative and instructional work. The Division of Information Systems of the CSUC is presently attempting to measure future goals and campus needs to update the present network.

It is my opinion that future networks should recognize the identity of each campus and should be designed to allow resource sharing without destroying their respective CAI development. A network of this type would capitalize on what already exists and would encourage cooperation among campuses. The format of the network, in that case, is less critical than the notions of cooperation, sharing, individuality, and the like. The network could be tied to the central office (Figure 5) or it could be completely connected (Figure 6) so that any campus communicates directly with any other institution in the system. In other words, there is no need for a central office to sanction, direct or create a system which may have developed naturally and is based upon need. However, collecting and disseminating information by a central office concerning mini-CAI work will informally tie institutions into a network if one does not already exist. A mini-CAI network would create an awareness of mini-CAI work throughout the state and would avoid unnecessary duplication and omission; thus increase the utilization of existing resources to enhance teaching and facilitate learning. The existence of a network could also be used to encourage campuses to further develop CAI work with a type of software that requires the minimum amount of time and effort to duplicate on another system; thus solving transferability problems.

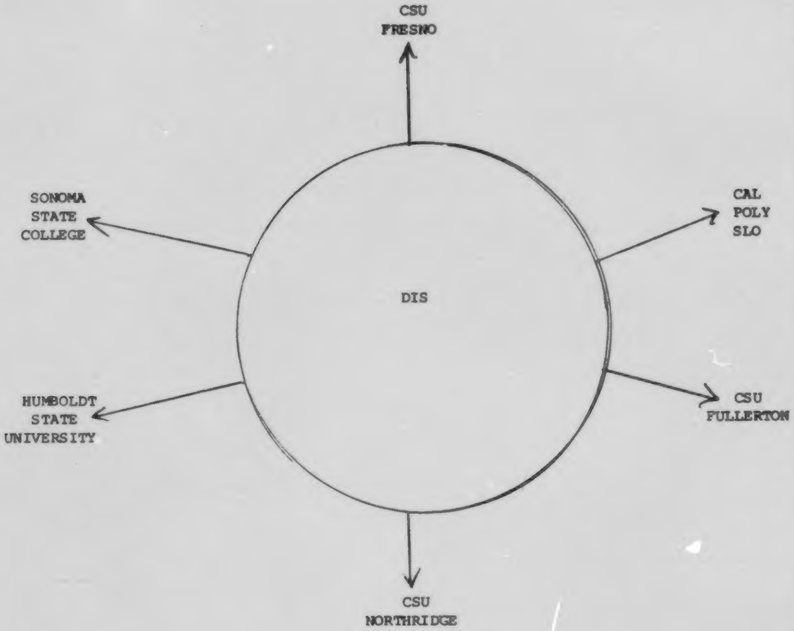
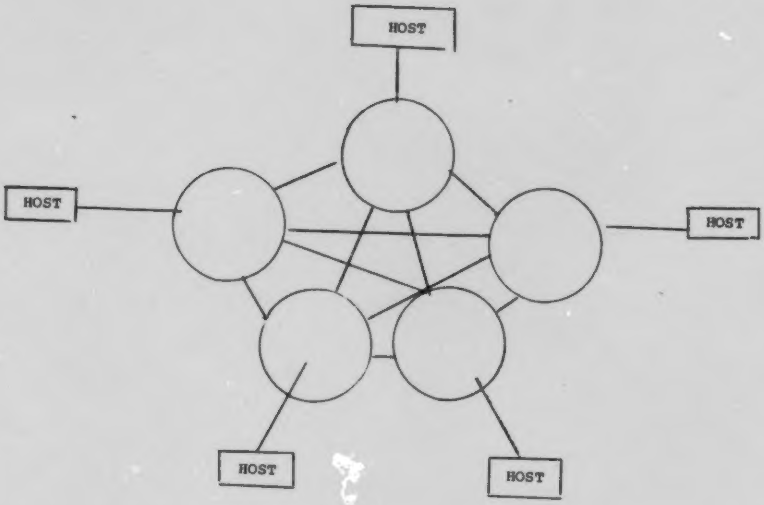

CSU FRESNO
SONOMA STATE COLLEGE
CAL POLY SLO
DIS
HUMBOLDT STATE UNIVERSITY
CSU FULLERTON
CSU NORTHRIDGE

FIGURE 5

99


HOST
HOST
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HOST

COMPLETELY CONNECTED NETWORK

FIGURE 6

100

III. CONCLUSION

Encouraging CAI activity on mini-computers, encouraging networking and so on, is just one small piece of the pie. I see microcomputer systems interfacing with other instuctional media equipment to provide expanded educational opportunity in California. Our media and learning centers could utilize mini's and micro's not only for billing and office work, but to interface with photographic darkroom equipment, film editing, television studio, and the like. Microprocessors could be used to store important reference information necessary to the production of mediated instruction and they could be used to compile time consuming utilization statistics; thus freeing our professionals to engage in substantive research, instructional development consultation, and professional renewal. And again, when this is proven successful on individual campuses, it could be the basis for establishing a network.

The importance of mini-CAI work for our institutions is being discussed not only by computer scientists and computer center staff, but it is now a concern of faculty, instructional developers, support staff, and administrators. The establishment of an informal or formal network precludes the transferability of mini-CAI work throughout our system; thus the expansion of educational opportunity is tied to your willingness to share your work and resources.

An Interactive Testing/Teaching System
for Microcomputers

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Abstract

An autonomous computer-assisted testing system has been realized through programming a portable computer system in APL. Indefinitely expandable auxilary storage for testing items and programs or scores is provided by alternate use of a pair of removable cartridges with tapes of 204 kilobytes. A single cartridge provided an item pool of nearly 100 items. Each item consisted of a question, correct answer, and reinforcement. The second tape stored user programs plus up to 107 files, each with up to 20 sets of indices and scores for 15 randomly selected questions. Cathode ray tube display of questions and reinforcement and real-time checking of answers is followed by recording partial scores and updating the number of trials by each student on each exam. The system provides a self-contained, portable and economical facility well suited to variable-paced, proficiency-based courses of study. Results of the experience gained in designing and using the system are included with conclusions based on more than two years testing with typical classes.

An Interactive Testing/Teaching System for Microcomputers

Introduction

Currently available implementations of high level language on portable, desk top sized computer systems equipped with significant main and auxiliary storage are rapidly expanding opportunities to create elaborate programs which control and tailor the presentation of learning items. With these new compact systems the per-student-hour cost can be five to ten times lower than that currently realized with CAI delivered by large computer systems.

This paper presents the results of experience gained while designing, implementing and putting in regular classroom use, an autonomous IBM 5100 computer system for testing, scoring, and providing reinforcement. The item pools used in the development of the system were adapted from the instructor's manual accompanying Biehler's (1974) textbook: Psychology Applied to Teaching.

The system, as currently implemented, affords a practical and economical opportunity to explore objectively, the effectiveness of computer delivered testing, and its effect on achievement in a proficiency-based mastery learning course of study that both employs partial scoring and permits time-variable pacing. Proficiency-based implies that the study for a course is directed towards the goal of attaining prescribed-in-advance levels of test score totals on a preset number of tests. These levels if achieved within a limited number of trials earn designated final letter grades. Partial scoring means that points are awarded for any correct responses that are obtained after one or more wrong answers until all alternate choices have been exhausted.

Because the mastery learning system of instruction allows students to arrange to take a test both as soon and as often as they feel prepared and also because the rate at which subsequent questions are received depends directly on how quickly the last question is answered (which is totally under the control of each student), the variable pacing automatically geared to the students' ability is an important feature of the system. This has been made practical by the economical implementation of the testing and reinforcement system on an IBM Model 5100 portable computer. The low cost of the system permits nearly unlimited access to testing and reinforcement at convenient times.

Hardware Configuration

The system used is a completely self-contained IBM 5100 portable computer configured with 32,768 eight-bit characters of main memory and a read-only memory containing an APL interpreter. The device is equipped with a single built-in tape drive and CRT video screen with 14 64-character lines of display. Auxiliary storage was provided by removeable tape cartridges, each capable of storing over 204,000 characters. One tape cartridge serves to store the system of programs and all item numbers and scores earned by the students for all trials of the tests associated with a single course. An additional tape cartridge capable of storing up to 107 test items was required for each test in a course. This hardware configuration is highly compact and portable, requiring for operation nothing more than a three ampere source of 110V ac power. Since only the video display is used, no paper or other hard-copy medium is necessary.

Identification of System Functions

The complete testing system contains three sets of primative functions.

These sets of functions are identifiable with three classes of computer users. The first class represents the instructor who creates and/or improves testing items. The second class represents the students who at the computer make trials at answering random subsets of questions on each of several tests. The third class is the educator or research worker who uses the computer to analyze the performance of students and testing items.

The necessary functions identified for each of these three classes of users are listed in the following subsections:

Instructor's Item and Score File Maintenance Functions

1. Create or improve test item files.
2. Mark, tag and initialize score files.
3. Setting of testing parameters.
4. Validation of identification numbers for admitted students.

Student's Testing Program Functions

1. Identification of Student.
2. Checking for valid admission and exceeding limit on trials.
3. Seeking and identification of question tape.
4. Introduction of student to testing objectives.
5. Generation of random test item numbers.
6. Sequencing of testing item numbers for retrieval.
7. Retrieval of components of a single test item.
8. Presentation of individual questions.
9. Limit checks on numbers of question attempts and test trials.
10. Recording of scores for each trial.
11. Updating of status trial number for each student and test.

Researcher's Item and Student Score Analysis Functions

1. Setting of constraints defining the subsets of the scores of interest.
2. Identification and selection of score subset meeting constraints.
3. Delivery of selected score subsets to statistics program.
4. Histogram data acquisition and display.

Organization of System Functions

Overview of Testing Functions

The testing system was implemented in terms of variables and functions defined in the array processing language APL (Iverson and Falkoff 1957) for which interpreters are widely available on most major computer systems and a growing number of smaller and portable systems. The names of the thirteen functions that manage the presentation of questions, answer checking, and recording of scores are APPEND, ASK, DELAY, FETCH, FORMAT, IDT, INTRO, LABEL, PAC, QUIZ, SEEK, SHOW, STATISTICS, and STUDENT.

Testing is initiated by the keyboard entry of the function name STUDENT. This function first calls the function IDT provided for identifying the tapes and students. With the repeated use of the function ASK, the IDT function obtains the date and the number of the test that is to be taken. The student's first name is also requested to enable the student-program dialog to be personalized. Beside acquiring these data, the function also evokes another function called INTRO which presents text explaining the testing system to the student. Finally, after checking that the student is not attempting to exceed the maximum number of trials permitted for the particular test specified, the function IDT either rejects the student or calls the function SEEK to seek the appropriate question tape. On succeeding to sense that the correct tape is present, SEEK returns control to the initiating function STUDENT.

A message is then presented to alert the identified and accepted student to anticipate the arrival of the first question. The DELAY function permits this message to be displayed on the screen momentarily before STUDENT finally calls the function QUIZ which then uses the following global variables as indicated:

COURSE --- number of the course file open for testing

DA --- number of the day of the month

DISPLACEMENT --- number of files before first student or item file

FN --- first name of the student being tested

IDN --- number by which the student is identified in the course

IDNOS --- 3-D bit array indicating status on admission and number of trials by test and student

MO --- number of the month in the year

NTOTAL --- number of random question in test pool

QUESTIONS --- number of questions to be randomly selected

TEST --- number of the test for the course

D --- identification number, displacement, number of files, random link

Utility Functions for Test Creation and Score or Item Analysis

The system for identifying, controlling testing, and score keeping is made generally useful with several additional supporting functions that are not needed during normal use of system in testing. For this reason, we will only outlive their general function rather than explain every instance that they are evoked for tagging new files or selectively retrieving specified subsets of the scores already stored.

ADMIT --- permits instructor to validate the identification number of any new student to be tested

ASK --- repeatedly requests entry of numerical or literal data until it conforms with controls imposed on type and number and length

FIX --- line editing function for altering lines of text within the items

FORMAT --- puts item numbers and scores in proper format for display

HEAD --- creates heading for viewing of scores

NEWCLASS --- resets all history of previous course admissions and test trials to zero

MBR --- tests if vector elements are members of intervals for selecting subsets of scores from files

PASSWORD -- produces exit from function NEWCLASS if no proper password is provided

PUTQAF --- inserts all components of a test item into a file

SELECT --- resets constraints on which subset of student scores are to be inspected

SELECTOR --- determines whether or not members of the file retrieved fit the constraints

TAGFILE --- labels all score files with course and student numbers

TEXTIN --- assists with building of regular arrays for test items

UPC --- unpacks character representation to produce a numerical form

Test Management Functions

The central function of the system, QUIZ, manages the presentation of questions, checking of answers, display of feedback or reinforcement frames and scoring. After generating a random set of numbers for choosing items, this function calls the function GETQAF which selects the file containing the correct item and checks the label on the file for the proper course and item numbers. If both numbers are right, the function fetches the three item components QQ, AA, and FF. These variables provide the question, answer, and feedback frames, respectively. QUIZ repeats the presentation of the question up to four times until the answer provided by the student matches with the content of AA. At that time, the item number and score are placed in an array named SCORE, by the function STATISTICS. QUIZ then displays FF, the feedback frame to reinforce the students' ideas about the completed question, proceeds to the next, if any, remaining items, numbers to present sequentially again the question QQ, checks the answer AA, and finally provides FF the feedback.

Upon completion of all or more than half of a preselected number of test items, the QUIZ function requests that the tape cartridge used for storing scores replace that tape storing the items and calls the function SEEK which then confirms that indeed the correct tape cartridge has been inserted. If not, SEEK repeatedly asserts that the wrong tape has been sensed until the proper one is in place.

The function APPEND upon being provided with the student identification number, computes the proper address of that student's file and evokes the function FETCH to retrieve a packed copy of all the old scores of the student previously recorded. These old scores are then rewritten back to the same file and followed by the new scores prefixed by eight elements of identifying information. These elements are: (1) a zero for flagging the beginning of each new record; (2) the identification number assigned each student for that course; (3) a two-digit number for the year; (4) the course number; (5) number of the month; (6) number of the test in that course; (7) number of the day; and (8) a sequence number indicating on which trial, of that particular test, for which the attached scores were achieved.

Upon completion of the filing of the students' new scores, the three-dimensional array of bits IDNOS with dimensions corresponding with information on test number, status, and student identification number is modified. Each time the two last-bit positions of the second dimension are incremented to reflect the number of times that each student has completed a trial on each particular test. This information is preserved for limiting the number of trials that a student is permitted to be tested with replicates of items for each test. Also, the first bit of the second dimension of the array IDNOS is currently used to indicate if the student number is validated to take all tests. Alternately, this layer of the array could be used to control selectively the admission of specific students to specific tests.

An auxiliary program named STATUS has been created for checking the bit array IDNOS to show what stage of testing the various students have reached.

Upon completion of score recording, QUIZ evokes the function SHOW which displays the scores earned for each test item and the percentage of the total score. The tape with the scores is then relabeled to reflect cumulative changes in a random link used for item sampling and the status of array IDNOS, indicating the status of testing for all students in the course. Before exiting from QUIZ and finally STUDENT, instructions are given to the student as to how to view his scores again or to proceed to another test or replicate trial of the current test.

Observations on Implementation Decisions

The preliminary design of the testing system used an IBM 5100 computer initially configured with only 16,384 characters of main memory. This version did not include functions required for both identification of the students and tests and the storing of scores. A single tape cartridge of auxiliary storage was used at first to store the system of programs and each item pool of test questions, answers, and feedback frames. After gaining experience with the single tape system, the design considerations of a two-tape system with score recording were established. Assuming that the question, answers, and feedback would require storage for up to two CRT screens (each of 14 sixty-four character lines or a total of 1792 characters) and recognizing that tape files may be marked only in multiples of 1024 characters, it is observed that the optimum file size must be either 1024 or 2048 characters. Choosing mixtures of these two file sizes yields a range of 81 to 136 for the number of items available from a single cartridge. In view of the fact that the number of items in a single test tape need not in practice exceed 128 or at most 256, question numbers can be represented in storage as single characters. Also because the course, test, student, trial, year, month, and day numbers can be specified by integers in the same range, they too, can be stored as single characters. Thus if 1024 character files are established for storing sets of 15 scores each with eight characters of identifying information, one can expect to store nearly 1024/(8+2x15) or approximately 26 such sets of scores in each of 107 student files. For each student a single 1024 character file would be sufficient to store all such sets of scores from a maximum of three trials on each of up to eight tests per course.

To introduce into the system a second tape to permit the storage of scores, it was necessary to implement functions that would identify both the tapes and the students, then interactively acquire other test identifying information needed to manage the creation and modification of score files. Tentatively this necessitated expanding the main memory of the IBM 5100 from 16384 to 32768 characters.

It has been found that with proper tuning of both the input functions for retrieving questions and the output functions that append scores after each test, it is quite practical to realize an economical testing system capable of delivering randomly selected items at a rate of 30 to 45 items per hour.

Conclusions

System Design Trade-offs

With the arrival of portable computer systems offering high level languages such as APL and significant amounts of fast main memory and large files on removeable auxiliary memories, it has become possible to implement economically, significant stand-alone testing programs. The memory sizes now available range from tens to hundreds of thousands of characters. The cost of fast, main memories now available is less than 20 cents per character while that of auxiliary storage from cartridges of magnetic tape is less than 0.01 cents per character. The availability of high-level language interpreters via read-only-memory now makes it possible to implement sophisticated systems with reduced requirements for high-speed main memory. In the implementation of this system, a reduction in the requirement of a single module of 16,384 characters of main memory can be traded for 30 million characters of auxiliary tape which is useful for the storage of teaching items and scores. This amount of auxiliary storage when used for testing items and reinforcement can accomodate 150 different tests of approximately 100 items each. With the current arrangement of 5 tests per course it is possible to provide storage for 30 courses at 100 dollars per course in place of an additional main memory module of 16,384 characters. Economies in the requirements for main memory are readily realized by implementing sophisticated CAI application with the highly structured and concise functions of APL.

Time-Variable Mastery Learning Environment

Computer delivered testing, with low-cost portable computer systems, has been demonstrated to have the advantages of permitting self-pacing and providing an ideal vehicle for organizing mastery learning courses of study. A previous paper found that students undergoing such treatment scored higher on achievement examinations, perceived that they had learned more, and accomplished significantly more out-of-class course-related activity than did a control group (Evans and Surkan, 1977). The magnetic tape storage of the item texts, combined with electronic editing from the screen of a CRT, allows continuing course refinements through additions to or deletions from the items. Also using the auxiliary storage and program control in testing makes it practical to record scores automatically, for all the randomly selected items, grouped along with complete identifying information. The completeness of the score records makes possible, subsequently, extensive analysis of individual item and student performance.

The results of such analysis serve as a source of feedback information for improving the items and for monitoring the progress of individual students. Consequently, this system has been found most satisfactory as a vehicle for testing and instruction in a mastery learning course of study. The consistency of computer testing and the practicality of the unlimited availability of a testing facility that is necessary for self-pacing has led to continued refinements in using of the system and to the extension of its application to a second course in the 1976-1977 fall semester, and a third and fourth course during 1977-1978.

References

Bieler, R. Instructor's manual to accompany Psychology applied to teaching. Houghton-Mifflin Co., Boston, 1974.

Block, J. H. Mastery learning, theory and practice. Holt, Rinehart and Winston, Inc., 1971.

Evans, R. M., and Surkan, A. J. Effect of computer-delivered testing on achievement in a mastery learning course of study with partial scoring and variable pacing. *Proceedings, Eighth Conference on Computers in the Undergraduate Curricula*. East Lansing: Michigan State University, 1977.

Falkoff, Adin D., and Iverson, Kenneth E. The design of APL, *IBM Journal of Research and Development* 17, No. 4, July 1973, pp. 324-334.

A Microprocessor Based CAI System with Graphic Capabilities*

by

Frank J. Mabry, Andrew W. Appel and Allan H. Levy, M.D.

I. Introduction

With the invention of the microprocessor chip, the economic restraints to personal computing have been substantially removed. Our laboratory has been concerned with developing microprocessor based systems that are useful in education. We recognize that not all educational computing can be done well on a stand-alone basis; indeed, a user community actively participating in the interchange of information is an important component of the educational process, involving both feedback for the creation and evaluation of educational material. However, there are many aspects of the operation of a Computer Assisted Instruction (CAI) system in which such a system should function efficiently and adequately on a stand-alone basis, free of the costs of continuous communications.

With this in mind, we have developed a system which operates in a dual mode, on an independent basis, as well as connected to a communications network. We have constructed a hardware-software system which allows a standard PLATO IV (1) terminal to act as an independent computing system with the aid of a microprocessor equipped with digital cassette tape drives, and also to access remote systems, including PLATO, as well as standard teletype-like systems.

The PLATO system (2), developed by Bitzer and associates, has been a model for user flexibility and for the effective use of graphical techniques. Our system, in stand-alone mode, attempts to capture these attributes as far as possible.

II. Background

The Medical Computing Laboratory (MCL) of the College of Medicine at the University of Illinois has been involved with service delivery of computer based instruction to units within the College of Medicine, as well as outside the University via terminals connected to the PLATO system (3). Simultaneously, MCL research activity has been directed towards investigation of alternative forms of CAI delivery.

Significant progress has been made by Chen (4) in the development of a "local node" of computation with the potential for support of a 30-50 terminal CAI system, roughly equivalent in function to the larger PLATO system. Noting the ongoing development by Chen, the problems surrounding use of the existing medically oriented CAI systems, including single terminal systems, took our interest. We have attempted to develop a system with the capability of accessing teletype-like (ASCII*) communication systems and the PLATO system. The new system also was to be capable of stand-alone support of CAI activity and, in particular, should support the CAI language PILOT (Programmed Inquiry, Learning or Teaching) as specified by Starkweather (5).

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The hardware configuration is detailed in Appendix A and shown in Figure 1 and includes the following:

- IMSAI microprocessor (based upon an INTEL 8080 microprocessor chip)
- 16K (K=1024) bytes of storage
- ASCII bi-directional communication ports (two)
- 1 millisecond interval timer
- Vectored interrupt driver
- Dual digital cassette tape drives (6)
- PLATO IV terminal and interface.

The software configuration used provides software to access CAI systems using teletype-like communications (e.g., Coursewriter on IBM systems or MUMPS on DEC systems). The software system also provides a BASIC** interpreter (referred to as NSBASIC [Not-So-BASIC]) which has extensions for allowing local programs to utilize the native capabilities of the PLATO IV terminal in a stand-alone mode. The capability remains for the PLATO IV terminal to access the CERL (Computer Based Education Research Laboratory) PLATO system which can be accomplished by a single switch setting on the system.

The general memory configuration and requirements of the system are given in Figure 2. A brief syntactic description of NSBASIC is given in Appendix B.

III. NSBASIC [Not-So-BASIC]

Beginning with an interpreter which provided the rudiments of the BASIC language, we have made extensions to support access to the native features of the PLATO IV terminal (particularly graphics), to allow "judging" of interactive responses, to provide program and data management primitives, and to facilitate communication under local program control with remote terminal systems.

The graphic extensions that have been added provide for line drawing (DRAW), absolute positioning (AT) and setting display mode (MODE). The DRAW statement allows the programmer to indicate the end points of one or more line segments. The coordinates of these end points may be any NSBASIC numeric expression. This allows the use of constants, expressions and/or variable reference. The AT statement both influences the beginning point of the next DRAW statement and where text is output in subsequent PRINT statements. The MODE command is used to indicate how output is to affect the present display. In mode "write" the dots of the display (512 x 512) are illuminated. In mode "erase" dots are turned off where lines or characters are displayed. Mode "rewrite" indicates that the 8 x 16 dot area associated with character output is to be erased before a new character is displayed.

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*ASCII - American Standard Code for Information Interchange.

**The BASIC Interpreter was written by Dr. Paul Tucker at CERL. It has been modified and extended in the course of the work described here.

Obviously CAI is more than graphics. Moreover, flexible student response judging is an important factor in providing effective student-computer interaction. In order to support sufficient capacity for interactive response processing new character string manipulation statements and functions were added to NSBASIC. The capabilities designed into these statements were influenced in roughly equal amounts by the capabilities found in PILOT and TUTOR*. As an example, the NSBASIC "MATCH" command allows a programmer to specify a list of words of varying length to be checked for in a string variable. The command indicates which word of the list (if any) was found and where it was found in the string. This facility allows a lesson author to specify lists of words that should or should not be found in a student's response and easily specify checking for their existence.

Many of the language primitives which were developed with response-judging in mind, have been useful in the development of both the PILOT translator and the graphic editor. For example, commands, such as MATCH, MOVE and FIND operating on strings can be used both to judge an interactive user response or to determine what source statement should be generated based on the character string value of a program statement which can be read as data.

Most users experienced in the PLATO system have come to expect "single-key-response," particularly when moving through multiple choice sequences. The facility for the programmer to direct massive display changes based upon a single keypress is widely accepted as a significant accomplishment of the system. Such sequences are successfully used at many points in student interaction to enhance the feeling of existence in a "friendly environment." NSBASIC provides several facilities to allow the programmer to support such user options. The "KEY" statement returns characters from the user one at a time as keys are pressed on the keyboard. An "ONFUNC" statement allows the programmer to establish a "flow-of-control" sequence to be invoked if any of the function keys on the PLATO IV terminal are pressed. In the event a function key is pressed, a function "FKEY" is available to allow the programmer to determine which specific function key was used.

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*TUTOR is the programming language used for lesson writing on the PLATO system.

With the construction of the digital cassete drives and development of software for access to program and for data storage, program development support services were placed in the NSBASIC interpreter. Statements which support program storage, retrieval and linkage (DTSAVE, DTREST, DTLINK) were added. Each of these statements accepts two parameters. The first indicates a relative beginning block (each block is 256 bytes long) to access. The second parameter indicates which of the two drives to access. When a program "link" is requested the interpreter will read in the requested program and then begin executing at its first statement. The storage and retrieval facilities provide for control information to be recorded or utilized which specifies the program's length. The program storage and retrieval commands are generally used in "immediate" mode while the linkage facility may be incorporated to move between programs.

Data storage and retrieval is accomplished via the "DTREAD" and "DTWRITE" statements. The programmer specifies the information's location, length (in blocks of 256 bytes) relative block and drive number. The initial use of these statements was in the PILOT translator (described in section IV). Program source written and saved as though it were text, can be read as data translated in memory and written back as data for subsequent use via a DTLINK command.

This same approach was used to support the graphic editor (section V), a program merge utility, macro utility, stand alone 8080 assembler-loader and a source listing program.

IV. Microprocessor-supported PILOT

Following the addition of the string manipulation statements to NSBASIC, an NSBASIC program for translation from PILOT source to NSBASIC source was written. In essence this allows a user of the terminal to utilize the existing editing functions of the NSBASIC interpreter to enter the source of a PILOT program. The same constraints and capabilities as those found in Appendix B can be used in construction of a PILOT lesson. Following the entry of such a lesson, the standard editor supported function for program storage is utilized, and the use of the program linking function allows the initiation of the NSBASIC translator. The translator inputs the source of the previously written PILOT lesson treating it as data and translating it in a line-for-line process into NSBASIC. Following the successful translation of a PILOT program into NSBASIC source, the translation process is not required for subsequent uses of the lesson.

In addition to the core PILOT described by Starkweather in his PILOT-73 statement, an escape to NSBASIC was provided for in the translator. This feature, although not absolutely necessary, did allow immediate testing of the integration of PILOT source with graphic primitives and provided for early testing of concepts which seem appropriate to any implementation of graphics in a PILOT environment.

V. Graphic Source Generation

In the course of experimenting with the stand-alone processor connected to the PLATO IV terminal and following the development of statements necessary for PILOT translation, a graphic editor was developed much like that found on the PLATO system (2). The microprocessor-based graphic editor provides for cursor movement with the directional keys. The cursor movement may be either in fine steps of one coordinate value per key stroke, or with the use of the shifted directional key 10 coordinate values per key stroke. Also, the cursor may be moved by use of the terminal touch panel. The graphic editor allows the user to identify specific points on the screen and to establish lines between these points. A user may also specify text to be displayed. Also available from graphic editor is the present numeric representation of all of the generated display. If, due to various display options, the display becomes obscured by other information displayed simultaneously, the graphic editor provides for regeneration of the graphic display after initial erasure of the screen. A help sequence is provided for the user explaining each of the options and how to actuate their use. Following the generation of a graphics display under the graphic editor, the user may request that a source be generated which accomplishes the display described to the graphic editor. This source may be used subsequently with an existing program. The integration of such source with existing programs is supported by a merge facility. Figure 3 portrays the steps in the graphic generation process. Figure 4 shows a display generated by the graphic editor which has included the user invoked "help" sequence and shows the subsequently produced NSBASIC source statements.

VI. Sized Writing and User Defined Special Characters

On the PLATO system, a programmer can specify that the display panel be used as a writing tablet for large or small letters. The actual characters written are specified by the standard "write" statement. This writing process is influenced by sizing and rotation commands.

We felt that this capability would be useful on the microprocessor based system. However, the sized writing function requires significant computation during the display process. In order to implement this capability on the microprocessor system with its appreciably lower computational power, a line writing editor was developed which executes the various "DRAW"s and "AT"s in advance, saving the graphic description for use with actual lessons. The description created by this process can be inserted into programs as source. The major functional difference between the preprocessed approach used on the microprocessor and that used on PLATO is the inability of the microprocessor system to display variable information. This is generally mitigated by the tendency on authors' parts to use sized writing for titling and descriptions which don't require an ability to display variable information.

The PLATO IV terminal has the capability for loading user defined special characters. These characters can be developed and edited on the PLATO system. The characters are formed within an 8 x 16 dot area. This facility has been used by lesson writers to enhance textual display (e.g., italics), in animation sequences and in display of special notation (e.g., chemical symbols or mathematical notation). Characters developed for such use are loaded into alternate character memory on the PLATO IV terminal by the central PLATO system.

In order to provide access to this graphic capability of the terminal a combination of microprocessor software (in NSBASIC) and software on the PLATO system was developed. The PLATO system software we developed provides a translation and transmission capability. This software accesses existing character set definitions and translates them into character sequences which are sent via the external output facility of the PLATO IV terminal to the ASCII input channel on the microprocessor. The microprocessor translates the character sequences received in this manner into the appropriate data to be transmitted for loading into the terminal when the specific user defined character set is desired. The data is saved on digital tape and can be loaded into the terminal by use of the NSBASIC "PRINT" statement.

VII. Programming Support

As with larger systems, the microprocessor based system has fostered development of programmer support services as programming has been underway. Support services have fallen into four general areas: aid for the programmer in developing software in NSBASIC, assembly language support for the production of 8080 machine language routines, assists in conversion of PLATO system based lessons to the microprocessor system and the previously mentioned PILOT language translation program.

Services for access to graphic capabilities have followed closely those found on PLATO (see sections V and VI). NSBASIC programs have been developed which support program listing, source statement merging and context editing. The program listing facility has gone through several modifications to allow listing on two different hardcopy terminals with differing control sequences and a local computing system which has a high speed printer. In the latter case, the listing program includes the "job control" statements necessary for the computing system as well as programmed delays to wait for responses from the computing system, thereby providing proper synchronization with activities on that system.

In the process of developing new machine language support routines, it became evident that our dependence on a remote system for machine language programming was not practical. To alleviate this dependence, an assembler-loader for the microprocessor was written in NSBASIC. The source of an assembly language routine is entered and edited in the same manner as standard NSBASIC programs, but is translated by an NSBASIC program and loaded immediately into the memory it is to execute in. The assembler optionally produces a printed listing of the assembly. Errors encountered during assembly are displayed to the user indicating line number and error type.

Both because of the large amount of lessons existing on the PLATO system but appropriate in the microprocessor environment and because both systems use the same display device, we developed software on the microprocessor for aiding the conversion of such lessons from PLATO to the microprocessor. Using a PLATO system lesson which prints lessons on ASCII devices, software was developed which causes the microprocessor to read in the text being converted via one of its ASCII interfaces. The TUTOR source is converted to NSBASIC on a statement by statement basis. "AT" and "DRAW" statements have the minor syntactic differences between NSBASIC and TUTOR resolved. "WRITE" statements in TUTOR, which contain only constant information, are converted to NSBASIC "PRINT" statements. All other statements are prefixed as "REMark" statements, thereby allowing later conversion by the programmer.

VIII. Commentary

Development of Local System on a Microprocessor

Use of Dr. Tucker's BASIC interpreter has provided a "jumping off" point for local support software. The interpreter has not, throughout the course of our work, been felt to be an end but rather a base from which to extend as local needs became apparent. It has been this willingness to extend the statements supported by the interpreter which has allowed the rapid production of application software. It has allowed us to provide new statements to meet needs on several application and program support fronts simultaneously.

PILOT on the Microprocessor

The NSBASIC source program, which implemented the PILOT translation process, was written and implemented in a very short period of time due primarily to the interpretive nature of the language, and the fact that the string handling statements provided sufficient language power to rapidly translate the source. This same technique was utilized for developing the graphic editor and, to a lesser extent, the 8080 assembler-loader. The language primitives appear to have been the sufficient and necessary ones necessary for the completion of the translation tasks where the language "translated to" provides for a one-to-one mapping of the language "translated from." Had this not been the case, then in all likelihood the requirements in terms of primitives for translation would have been more extensive and required at a minimum table look up capabilities and the maintenance of such tables for variable and label reference.

Graphics in a Microprocessor Environment

An extension to the graphic editor, which seems worthwhile in light of the potentials for use of the microprocessor by an interactive user, is to allow the generation within the source of coordinate translation and scaling information. Following the specification of such information, the subsequent source generated can be utilized with multiple references to cause output in different areas of the screen by respecification of translation and scaling variables' values. Such a capability would not require internal modification of the actual source statements which would be more tedious than parameterization of translation and scaling information.

IX. Summary

A system has been developed which allows access to remote systems: PLATO and ASCII based communication systems. The system also has facilities for local production and use of PILOT lessons, for support of a generalized programming language (NSBASIC) and for development of graphic sequences. The capabilities required for both a stand alone CAI system oriented towards a single user and for a system which provides access to remote CAI systems has been realized.

***

The authors wish to acknowledge the support of research assistants in Medical Computing Laboratory who aided the developments described here. Mr. Tom Szolyga developed both the PLATO IV - 8080 hardware interface and much of the translation software. Mr. A. B. Baskin has aided in clarifying portions of input/output control code and in describing the theory of the translation process to/from ASCII and the PLATO IV terminal.

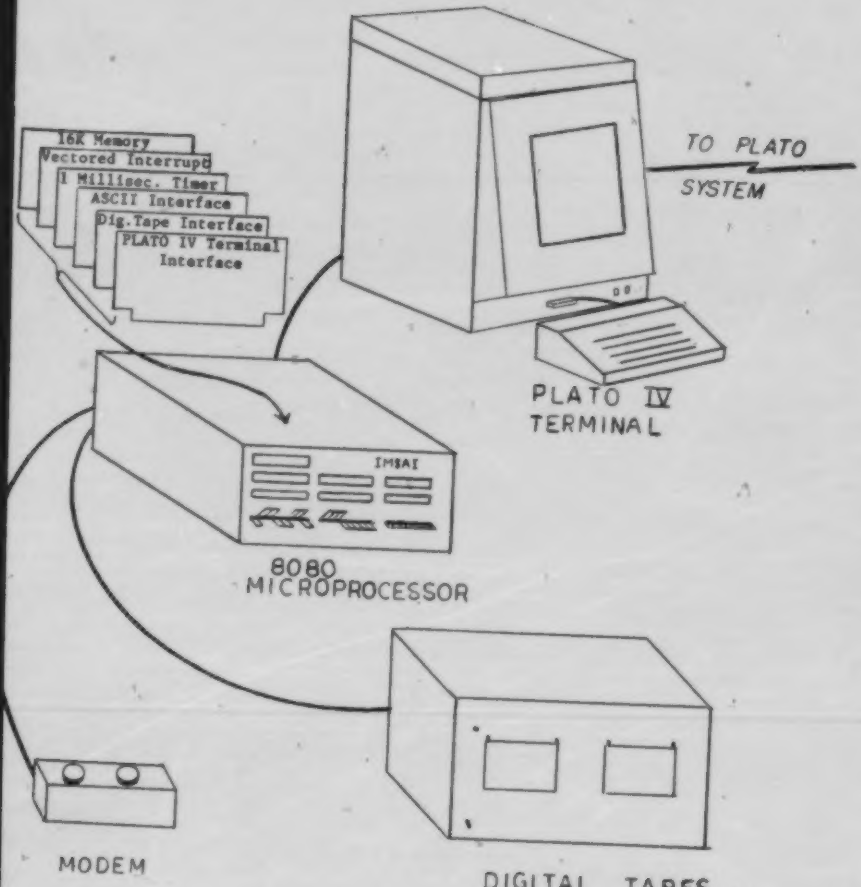

16K Memory
Vectored Interrupt
1 Millisec. Timer
ASCII Interface
Dig.Tape Interface
PLATO IV Terminal Interface
TO PLATO SYSTEM
PLATO IV TERMINAL
IMSAI
8080 MICROPROCESSOR
MODEM
DIGITAL TAPES

Figure 1

System Hardware Configuration

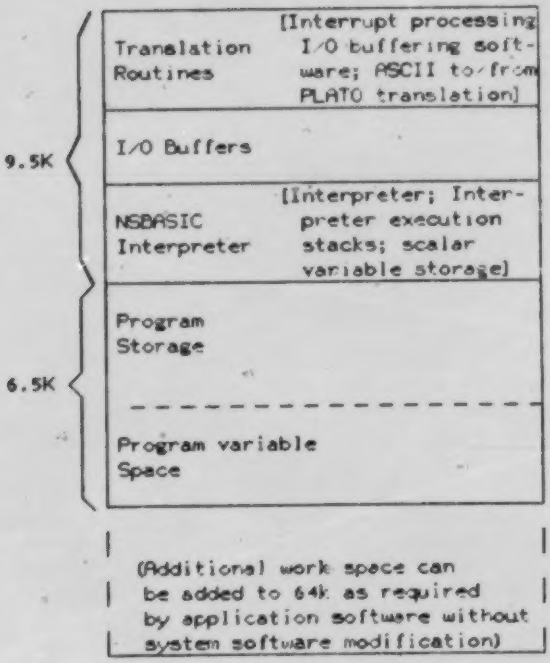

9.5K
Translation Routines
[Interrupt processing I/O buffering software; ASCII to/from PLATO translation]
I/O Buffers
NSBASIC Interpreter
[Interpreter; Interpreter execution stacks; scalar variable storage]
6.5K
Program Storage
Program variable Space
(Additional work space can be added to 64k as required by application software without system software modification)

Figure 2.
Microprocessor Memory Configuration.

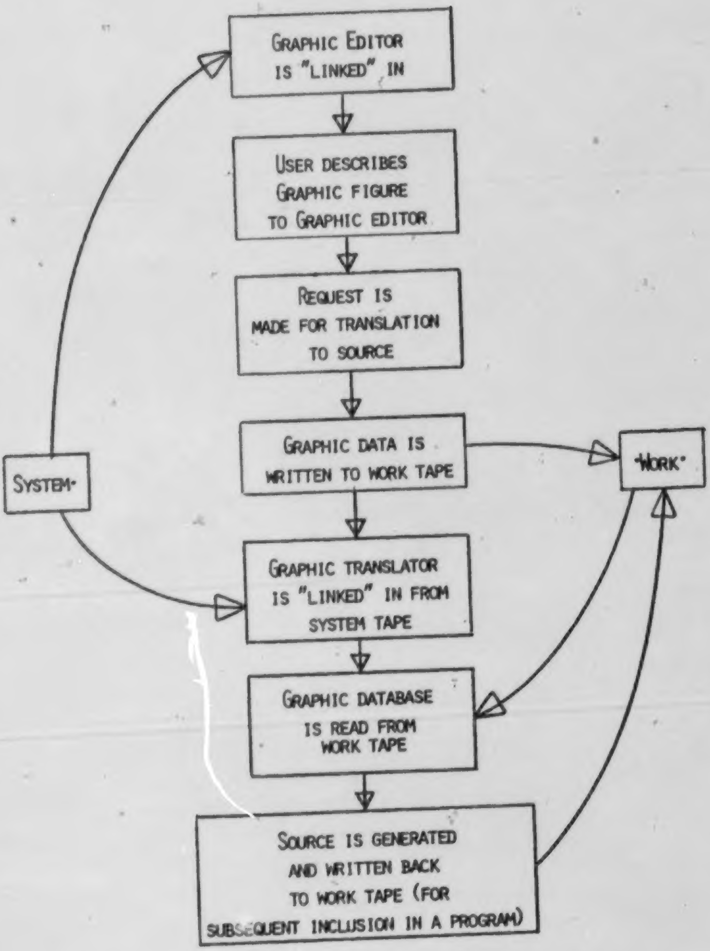
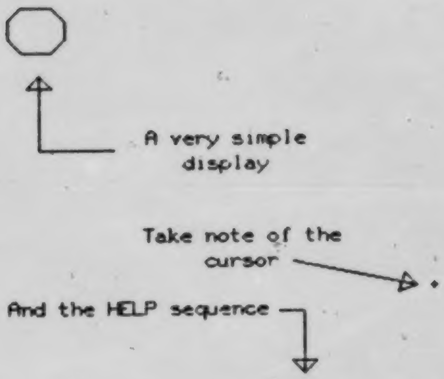

GRAPHIC EDITOR IS "LINKED" IN
USER DESCRIBES GRAPHIC FIGURE TO GRAPHIC EDITOR
REQUEST IS MADE FOR TRANSLATION TO SOURCE
GRAPHIC DATA IS WRITTEN TO WORK TAPE
"WORK"
SYSTEM
GRAPHIC TRANSLATOR IS "LINKED" IN FROM SYSTEM TAPE
GRAPHIC DATABASE IS READ FROM WORK TAPE
SOURCE IS GENERATED AND WRITTEN BACK TO WORK TAPE (FOR SUBSEQUENT INCLUSION IN A PROGRAM)

Figure 3

Steps in the Graphic Generation Process



DIRECTIONAL KEYS AS MARKED
'R'redisplay, 'I' for information, 'T' for text
'S'show present coords, 'L' line, 'P' point
'/' delete last graphic element; DATA1 source generation option; Touch is available for rapid cursor movement

- a -

```
30 AT80,402:DRAW(88,410;108,410;117,401;117,390;108,381)
32 DRAW(89,381;80,390;80,401):AT100,366:DRAW(92,358)
34 DRAW(108,358;100,366;100,318;148,318):AT169,318
36 P."A very simple":P."   display":AT167,255
38 P."Take note of the":P."      cursor":AT351,223:P."+"
40 AT263,246:DRAW(343,230;335,238;331,226;343,230)
42 AT80,208:P."And the HELP sequence":AT254,214
44 DRAW(270,214;270,174;262,182;278,182;270,174)
```

- b -

Figure 4.
a - Graphic Editor Display and "Help" Sequence.
b - The NSBASIC Source Generated for 4-a by the Graphic Translator.

References

1. Stifle, Jack. *The PLATO IV Terminal: Description of Operation*. Urbana: University of Illinois Press (1974).

2. Sherwood, Bruce A. and Smith, Stanley G. "Educational Uses of the PLATO Computer System." *Science* (1976) Vol. 192, pp. 344-352.

3. Levy, Allan H. and Williams, Ben T. "Experiences with Health Sciences Education Using PLATO." *Proceedings of the Society for Computer Medicine Conference*, November, 1976.

4. Chen, Thomas T., Levy, Allan H. and Williams, Ben T. "A Depository Health-Computer Network." *Medical Information* (1973) Vol. I, No. 3, pp. 167-178.

5. Starkweather, John. *PILOT Guide*. USC 03.01.03 (1976) USSF Computer Center.

6. *The Digital Group Cassette Storage System*, CSS-RO, The Digital Group, Inc., Denver.

Appendix A

Hardware Features

8080 CPU:

- mainframe manufactured by IMSAI
- inexpensive
- our configuration has locally designed hardware which provides vectored interrupts, one of which is a 1 millisecond timer (needed for coordinating the timing of graphic display processing between the microprocessor and the PLATO IV terminal)

16K Memory:

- used for storage of interrupt processing, translation software, buffers, NSBASIC interpreter and user program
- approximately half of software could be placed in "rom" but the development activity has required changes to this support software

Dual Digital Tapes:

- controller by Digital Group and cassette decks by PHI Deck
- 800 cps transfer rate
- we use the modified Digital Group software
- the controller coupled with software provides for access to 256 byte blocks. Each block is written with a unique numeric i.d. and is "read verified" after it is written (block also contains "lrc"). Blocks written via this system are prefixed with a pattern which is not found in data. This feature allows, together with the combination of "fast foward" and "fast rewind" and fixed block records, the system to optimize somewhat the access to data. This is because the tape head can be dropped at any time, and the present position relative to the beginning of the tape discriminated.

ROM Loader:

- ROM loader provides for loading system software from digital tape
- also loader from ASCII interface

ASCII Channels:

- two channels; independently buffered
- speed 110 to 9600 baud
- parity and number of stop bits may be set by software

PLATO Interface:

- provides vectored interrupt for keyboard input and completion of output
- is accessed for output as three memory locations; portions of communication's packet are placed in each of three words and as data arrives at the third memory word output begins

NSBASIC(Not-So-BASIC) Language Guide

AIN,@<string variable>,@<count variable>
Statement
<string variable> will receive any chars that have arrived with appropriate termination for a NSBASIC string.
<count variable> will be zero if no chars have been received otherwise will be number of characters received and transferred to <string variable>

AOUT @<string>
Statement
Sends standard ASCII out channel 0 from <string>.

ABS(<expr>)
Function.
Returns absolute value of <expr>

BINA,@<var1>,@<var2>,@<string>
Statement
Converts an alphanumeric string to a number.
<var1> receives 0 if <string>is not a valid number
receives 1 if it is a valid number.
<var2> receives the converted result.
<string>can be a string variable or "<characters>"

CLRS

Statement
Clears the screen and sets the next print location at the top left corner of the screen. This statement also sets the mode to mode rewrite(see MODE command).

CSTS

Function. CSTS is used to indicate when input (keypresses) are avaiable.
CSTS=0 if no keys are available
≠0 if keys are available.

DELAY <expr>
Statement
<expr> is the time in milliseconds to delay.

DESEL

Statement. Terminates IN/PRINT access to a string-area and causes I/O to be to/from the terminal (see "SEL" command)

DIM<letter>(<expr>),<letter>(<expr>),...
Statement. Creates 1-dimensional arrays.
DIM A(6)   creates an array 6 words(2 bytes per word).
Arrays can store strings(e.g.A(1)="Hello")or numbers(e.g. A(4)=5+1)

DO

Statement. DO sets a pointer for the OD command.
When an OD command is encountered an immediate branch is done to the last DO encountered.
For example the following assignment will be done 10 times:

```
        B=0:DO:B=B+1:IF B<10 OD
```

DRAW(<x>,<y>[<x>,<y>]...)
Statement. Draws from present screen position to the first <x>,<y> coordinate , from there to the next and so forth. <x> and <y> may be expressions involving variables or constants.

DTLINK,<begin_block>,<tape_drive>
Statement. DTLINK causes a new program to be read in from the digital tape drive(<tape_drive>) beginning at block(<begin_block>). After the program is read in execution begins with first statement. (Note: the scalar variable space is cleared as well as the array space; however, the user stack(accessed via PUSH and POP) is not modified.)

DTREAD,@<string var>,<# of blocks>,<start block>,<drive #>
Statement
Reads from digital tape drive <drive#> starting at block <start block> for <# of blocks> blocks into memory starting at @<string var>.
(One block is 256 bytes)

DTREST,<block#>,<tape#>
Statement. This statement causes the program at <block#> block of tape drive <tape#> to be read into the program space. Control is not turned over to the program. The user may access the program's source or start execution with a RUN command.

DTSAVE,<block#>,<tape#>
Statement. This statement causes the present program to be saved at block <block#> of drive <tape#>.
The length of the program is stored with the program and is used by the DTLINK and DTREST statements when reading programs into memory.

DTWRITE,@<string var>,<# of blocks>,<start block>,<drive#>
Statement
Writes to digital tape drive # (<drive#>), starting at block <start block> for <# of blocks> blocks from memory starting at @<string var> (note: one block is 256 bytes)(also note: this will wipe out data in a few blocks after the ones written).

ELSE

Statement
If the condition of the last IF encountered was false, the rest of the line is executed; otherwise, the rest of the line is skipped.
Example:

```
5 IF B=1 P."B=1"
6 ELSE P."B≠1"
7 ELSE P."B not equal to 1"
```

Would cause :
B=1   to be printed if B=1 otherwise
B≠1   and
B not equal to 1(also!)
(Note : both ELSE statements are executed in the false case of statement 5!)

END

Statement
Causes termination of program execution.
If the NSBASIC interpreter finds no more statements to execute it will display an error message; therefore, the logical end of a program should include the END statement.

ERR Function. This function returns the statement number of the statement which was executing at the last error. Reference to the function resets the value to zero until another error occurs. Flow of control in the program following an error may be specfied via the ONERR statement with the ERR function used to determine where or why an error occured.

FCTN(<expr>)
Function.
Evaluates the expression found at line# <expr> where <expr> is a valid NSBASIC algebraic expression.
Example:

```
30 LET B=2+FCTN(95)
95 5*A+2
```

FIND,@<ret_string>,@<token_list>,<expr>
Statement. The <token_list is of the form:

```
f b          b          b    b f
c c <token1> c <token2> c ... c c
```

where f/c and b/c are characters not found in any of the tokens. The token-character string corresponding to <expr> is copied to <ret_string>. If the <expr> is greater then the number of tokens in the <token_list> then the f/c character is placed in the <ret_string>.

FKEY

Function.
Returns value of last funciton key(not next or shift stop) that was pressed.

GOSUB <expr>
Statement
<expr> is line number for beginning of a subroutine
Warning! GOSUB returns to next line, so all code on same line AFTER GOSUB is ignored!
To return from a GOSUB, execute a RET statement.
GOSUB may be nested up to 4 levels.

GOTO <expr>
Statement
Program control is transfered to the line number <expr>. <expr> must evaluate to a valid line number.

```
IF
        Statement.
        Syntax is as follows:
        IF <expr><op><expr> <statement>[:<statement>]

        where <op> is any of <,>,<>,<=,>= and <expr> is
        either both-side arithmetic or string .
        If <expr> is a string variable only = is allowed.

        Example:
        IF $A(1)="abcd" LET C=C+1
        IF A<B PRINT "A<B":GOTO 12

        Note: if the <expr><op><expr> is false, NONE of the
        commands on the rest of the line are execute
        (including the GOTO 12 in the second example)


IN "<string>" <var>,<var>...
        Statement
        All tags are optional.
        <var> is numeric variable or
                $<string variable>.
        Multiple <var>'s are allowed only for numeric
        variables.
        An IN statement without tags will just wait for
        the NEXT key to be pressed.
        The <string> following(optionally) IN is used as
        a prompt.

IOP     function.
        Returns value of present SEL[ect] pointer for
        string-area I/O(see SEL command).

KEY <var>
        Statement
        Puts ASCII value of last key pressed into <var>.
        If there is no "last key" in the input queue, it
        waits for one to be pressed.
LEN(<string>) function
        <string> may be a string variable or "<characters>".
        The function returns the number of characters in
        string.

LET <var>=<expr>
        Statement
        <var> is A-Z,A1-Z6,A(1)-Z(1).
        <expr> is an algebraic expresion, "<string>" or
        $ <string variable>

MATCH, @<which>, @<where>, @<list>, @<string>
        Statement
        <list> is of form: ":, token1, token2, token3,...,:"
        (can be a string variable) <which> is a variable
        = 0 if no match
        = 1 if token1 found
        = 2 if token2, etc.
        <where> is displacement into <string> at which the
        token was found
        <string> is the string to search through (can be
        a variable or constant)
        The characters ":" and "," above could be any valid
        ASCII characters not found in any of the tokens.

MEMR, @<variable>, <location in memory>
        Statement
        Puts contents of <location> into low-order byte of
        <variable>,
        Puts %00 into high-order byte of <variable>

MEMW, <expr>, <location in memory>
        Statement
        Puts low-order byte of <expr> into <location in
        memory>

MOD (<expr1>, <expr2>)
        Function.
        value = <expr1> modulo <expr2>
        Example: LET B = MOD (A, 128)

MODE <tag>
        Statement
        MODE REWRITE    (or)    M.R.
        MODE WRITE      (or)    M.W.
        MODE ERASE      (or)    M.E.
        Mode REWRITE is the normal mode

MOVE, @<target>, <disp>, @<source>, <disp>, <#chars>
        Statement.
        Moves <# chars> characters from @<source>+<disp> to
        @<target>+<disp>.
        Turns off all end of string markers from @<target>
        to @<target>+<disp> turns on end of string marker
        in target at last char moved.
        NOTE: MINIMUM <disp> is 0
```

```
OD
        Statement.
        Returns to the last DO encountered
        See DO

ONERR <expr>
        Statement.
        After this is executed, if an error occurs a GOTO
        <expr> is done.
        Each ONERR is good for only 1 error: to reset just
        execute another.
        The system variable ERR contans the statement #
        where the last error occurred.
        To disarm ONERR, execute ONERR 0

ONFUNC <expr>
        Statement.
        <expr> indicates where control is to go in
        the event the user presses a function key (NOTE:
        not NEXT or shift-STOP).
        a ONFUNC <zero> disables.

POP
        Function.
        POP is a valid function. Pops number off user stac
        Example:  LET A = POP

PRINT <format><format><format>...
        Statement.
        <format> is:   valid algebraic expression
        "<string>"  or
        $ <string variable>  or
        % <expr> (prints 4 digit hex)
        !<expr> indicates how many characters to print
                from the next string constant or variable

        A comma between <format>s causes tabulation to
        next MOD 8 column.
        A semicolon at end of statement causes a carriage
        return NOT to be done.

PUSH <expr>
        Statement.
        Pushes <expr> onto stack
        Note:  stack is saved over program links!
REM
        Statement.
        All characters following REM in the line are ignc
        by interpreter.

RET
        Statement.
        Returns 1 level of GOSUB.
        See GOSUB

RND (<expr>)
        Function.
        If <expr> is 0 then RND (<expr>) is a pseudo-
        random number.
        If <expr> is nonzero then <expr> is used as a se
        for random number generation.


SEL <expr>
        Statement.
        This command allows user to specify that subsequ
        IN/PRINT statements read from/write to a string-
        area instead of the terminal  (see also:
              ; if expr >0 then expr is starting point
                of a string-area for I/O.
                if expr = 0 then   I/O is
                resumed within last area used.

                if expr <0 then (-expr) is the address
                within an  area where I/O is being resu

@<v>
        Function.
        Returns the address at <v>, (<v>) is a variabl

        <v> may be a "<string>" in the program source.

        Examples:  MEMW, 5, (@ B(5)) + 3
                   MOVE, @B(1), 3, @"ABCDEF", 4, 1
(%<d><d><d><d>)
        Function.
        <d> is a hexadecimal digit, 0123456789, ABCDEF
        Example:
                LET B(5) = (% 00A1)

(<expr>)  Pseudo-function.
        <expr> must be address of variable storage the
        is to be referenced in lieu of a variable name
```

Programming Notes

```
GROSS TO FINE COORDINATE CONVERSION
        w = Gross Coord.
        x = ,MOD (w,100)*8
        y = (32-(w/100))*16

CHARSET
        To load a charset located on block <b>, tape <t>,
        length <l>
        DIM C(l)
        DTREAD,@ C(l), <l>, <b>, <t>
        P.$C(l)

TOUCH   enable/disable
        to initialize:  LET T1 = (% 401C)
                        LET T2 = (% C71C)

        Enable:  P.$T1
        Disable: P.$T2
```

Programming Options

Command	Result
LIST	List entire program.
LIST <num>	List line <num>.
LIST <lo> <hi>	List lines in the range <lo> to <hi>.
EDIT <num>	Allows single line editing. The copy key is active and copies one character of the old statement text out each time it is pressed. A shifted copy key press causes the remainder of the original statement to be output.
<num>	Without further text causes the line number <num> to be deleted.
SIZE	Causes the present program memory requirements to be displayed as well as available memory space.
RUN	Initiates execution of present program.
BLITZ	Entire memory space is cleared of present program and the interpreter makes a "fresh start" with the user.

Maxi CAI with a Micro

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The potential impact of microelectronics on human society has been compared in magnitude to the impact of the development of the printing press and to the impact of the industrial revolution. However overblown such comparisons ultimately prove to be, there is little question that a microelectronic revolution is about to occur in CAI. Microprocessors already have been incorporated into sophisticated CAI terminals; microcomputers open the possibility of avoiding the large initial capital investment previously needed to initiate CAI, and microprocessors are making possible TV and arcade games of increasing complexity which are paving the way for public acceptance of CAI. Finally secondary schools which have thus far remained innocent of the computer are purchasing microcomputers for their advanced mathematics programs. As is the case with all technology, microcomputers can be used either effectively or poorly, a truism which is especially applicable to CAI. In this paper we describe an effective microprocessor-based CAI system which we have assembled, and we discuss our reasons for describing the system as effective.

We based the design of our system on two assumptions. First, a microprocessor-based CAI system must be able to deliver CAI of quality comparable to that delivered by the most flexible and powerful minicomputer-based systems; and second, the best CAI courses are those which have been tested by a large number of students and which have been edited repeatedly on the basis of this testing. Our second assumption implies that authoring, testing, and debugging of courses are activities which are not suitable for microprocessor-based systems; these tasks are better handled on larger, multi-terminal systems. Therefore we chose to create a microprocessor-based system for the delivery of CAI courses which will be written and tested on our existing terminal system. This eliminates the need for extensive editing and error-checking resources within the system, which in turn allows us to provide for delivery of top-quality CAI using a 20K byte microcomputer. Thus we have traded complete independence of the microprocessor-based system for maximum sophistication and flexibility of the delivered CAI. It is obvious that it will be relatively easy to add rudimentary authoring and editing capabilities to our system, and we intend to do this in future versions, thus converting it to a completely independent system. However, we do not intend to use these capabilities for writing CAI courses for the reasons discussed.

Our approach requires that the CAI language used on the microprocessor-based system either be identical to the language used on the authoring system or be a subset of that language. In the latter case the conversion to the subset should be primarily via machine translation. Fortunately our campus system, which we use for authoring, uses two languages for CAI which are well-suited for microprocessor implementation, PILOT and BASIC. WTS-PILOT-BASIC is described in the appendix. It is sufficient to note that we have been able to translate a variety of CAI materials from a variety of sources into this language, without difficulty and usually with improved response time. PILOT, which in its rudimentary, original form was developed for a microprocessor-based terminal, is especially suited to microprocessors in two ways. PILOT uses only a small number of op codes, and it uses a minimum amount of storage space. (It is interesting to note that most CAI languages use a large amount of storage to keep the data necessary to implement particular instructional strategies, and that space and time is used whether or not that strategy is in use.) BASIC - in some dialect - is at present the standard microprocessor computational language. Therefore we chose to stay with our current language combination for the microprocessor-based system.

Our initial thought was that the simplest implementation of a PILOT-BASIC combination could be achieved by addition of the PILOT op codes to an existing BASIC system. This approach was discarded for several reasons. Available microprocessor BASIC operating systems of sufficient power occupy at least 8K bytes of memory; addition of PILOT would require about another 4K. Moreover, these versions of BASIC do not include all the string functions necessary for implementation of a powerful match instruction. Finally, a crude analysis of existing CAI courses showed that a small minority of the instructions included BASIC syntax. We therefore decided to write an operating system which would handle all the PILOT op codes directly, and then to add the necessary parts of BASIC to this system.

ALL BASIC programs can be translated to a simple form of the language which uses only five instructions: LET, DIM, INPUT, PRINT, and IF — THEN. We chose to write programs on our minicomputer system which would translate existing BASIC programs into the necessary five primitive instructions. (Some instructions require hand translation, e.g. MAT, READ, DATA, OPEN.) Moreover, wherever possible we replace the BASIC instruction with the PILOT equivalent. Thus the BASIC is implemented as follows:

Elementary BASIC	Micro-PILOT
DIM	C: DIM
LET	C: LET
IF ( ) THEN	OP CODE ( ):
INPUT	A:
PRINT	T:

We should emphasize that the author need not be aware of either Elementary BASIC or Micro PILOT; the author in most cases can program in extended BASIC (and WTS PILOT) and rely on machine translation to make the conversion.

Our two assumptions also influenced our selection of hardware. Obviously we sought to design the lowest cost system which also provided the desired capabilities. The major choices here are bulk storage and terminals. Although very cheap cassette decks have been used for the home microcomputer market, they are not suitable for CAI. Reversible, high-speed, quality decks are still cheaper than floppy disks, but in our opinion the savings is not worth the loss of branching speed and subroutine accessibility which disks provide. We therefore chose to use a 300K byte floppy disk. Only experience will tell if the small 90K byte floppy disks would have been a better choice. The cheapest terminal would have been a modified TV monitor, but these are limited to a 16x64 format. Our courses are written for a 24x80 format, so we chose to use such a terminal through an RS 232 interface. However, there is nothing in the systems software which precludes use with the cheaper terminal. The remaining major choice was the microprocessor. We chose the Motorola 6800 because of the cost of the available 6800 based systems. However, other microprocessors are available and would be equally suitable. In fact implementations of this language on the Z80 are underway, and we plan to implement it on the 8080 if demand warrants it.

The resulting system is available in two versions. The minimum version implements all of WTS PILOT and BASIC with floating point, the four arithmetic operations, two-dimensional numeric arrays, and the standard set of BASIC string operations. This system occupies less than 9K of memory in 6800 code, so a 16K machine allows sufficient space for arrays and string variables. In the full version we add a complete set of scientific functions, string arrays, and disk-read and disk-write capabilities. This version requires a 20K machine (the standard SWTP 6800 with an additional 16K of memory).

In summary we have assembled a microprocessor-based CAI system of real power and flexibility. This system can be assembled from kits for approximately $2700 without a terminal. The system will be available during the demonstration periods, and we hope you will take time to test its capabilities.

Appendix: A Description of WTS PILOT

Four instructions comprise the central core of PILOT,

T: type the following text,

A: accept an edited answer and optionally assign it as the value of the following string and/or number variable,

M: match the answer with the following one or more acceptable answers or patterns, and

J: jump to the designated instruction.

To these are added the statements

R: remark or comment,

U: use a subroutine at the designated label,

E: end the subroutine and return to the place of call, and

C: calculate using the following BASIC statement.

We supplement these locally with

: continue the previous T: statement,

PR: a new problem or course frame,

XI: execute immediate the following character string as a PILOT statement, and

SJ: jump to a new segment, preserving symbols but clearing labels.

The values of arithmetic and character string variables can be included in the text of a T: command if preceded by a # or a $, respectively, (e.g., T: #X3, T: B). This feature can be used to send special characters to terminals for graphics control. For example, the sequence

```
C:   Let B$ = CHR(8)
T:   $B$
```

will generate a back space on the Ann Arbor terminals. One line of input is accepted during by A: instruction, multiple spaces are compressed to single spaces, automatic upper/lower case editing is performed as specified, and the response optionally may be saved in a string and/or numerical variable. The last response accepted can be compared with a specified pattern string which may include the special characters * to match one character, % to signify space or end, & to match multiple characters, and ! to match one string or another. The result of the match is either an internally kept yes or no.

Any command can be made conditional by adding the following between the command code and the colon following it:

Y the instruction will be executed only if the last match was successful.

N the instruction will be executed only if the last match was not successful.

E the instruction will be executed only if an error flag was turned on.

C   the instruction will be executed only if the last relational conditioner was true (see below).

digit 0 through 9 - the instruction will execute only when the last A: instruction has been used repetitively in the designated number of times.

In addition execution of any instruction is made conditional by enclosing a BASIC logical expression (relational conditioner) in parentheses between the command and its following colon. The command will be executed only if the comparison is true, (e.g., T(X<3):).

Any instruction can be labelled by an asterisk followed by from one to six characters, (e.g., *LAB1   T:).

The destination of the J: command is a label (J: label), a line number (J: number), the last A: (e.g., J: @A), the next M: (e.g., J: @M), or the next PR: (e.g., J: @P).

Three modifiers are used to modify the execution of particular op codes. They are

J modifier	MJ: Produces automatic jump to the next M - on a no-match condition.
S modifier	MS: Allows one mismatched character or one pair of characters to be interchanged without triggering a no-match condition.
H modifier	TH: Suppresses the carriage return and line feed at the end of the line.

There are some limitations on the BASIC statements which can be included directly in a C: instruction, but because one of the legal statements is the CALL statement, the C: instruction imbeds the entire extended BASIC language into PILOT.

Programs begin with a header containing the optional automatic features listed:

U to translate all input to upper case,
L to translate all input to lower case,
S to remove all spaces from the input,
H to enable the HELP command,
G to enable to GOTO command, and
W to erase the label table

Additional headers can be imbedded within the course.

Instructional Design Considerations of CAI for the Deaf

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ABSTRACT

This paper attempts to achieve two complementary goals. The major goal is to discuss design considerations of instruction for the deaf in the context of a specific CAI program to teach deaf children how to use a ruler. This includes the task, learner, and means analyses involved in the development of the program. The second goal is to extol the virtues of CAI as a medium or methodology for instructional design. It is argued that the capability to provide individualized and interactive instruction, to explicitly state instructional strategies and logics, and to monitor the results of instruction makes CAI a premier choice as a instructional design tool.

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Instructional design is an attempt to approach the construction and delivery of educational materials in a systematic and empirical fashion. The ultimate goal is to provide the most effective learning possible, that is, to formulate a set of principles which specify for a given student and learning task, the optimal manner in which to instruct. Clearly such principles must be reliable and reproducible if they are to amount to much.

At the present juncture, the science (or technology) of instructional design has not progressed very far in terms of developing such a set of principles. (Indeed, many educators feel that such a goal is *a priori* impossible.) It has been possible to specify heuristic rules which are likely to pay off in certain situations. What is lacking is a sophisticated medium or methodology which allows the exact recording of instructional strategies or logics used and provides detailed information on student progress and hence the effectiveness of the instruction. In fact, CAI can provide such a medium for instructional design activity.

The following discussion will briefly outline each of the three major aspects of instructional design and then consider each in terms of a CAI program to teach deaf children to use a ruler. The final section discusses aspects of implementing and testing the program which further illustrates the value of CAI for instructional design.

The three major aspects of instructional design.

Instructional design can be divided into three major aspects: task analysis, learner analysis, and means analysis. Each of these three aspects encompasses a domain of major instructional dimensions. A comprehensive instructional design will involve the dimensional interaction of these three domains. Figure 1 is a conceptual model which illustrates the interaction of the major dimensions of instructional design.

Task analysis is concerned with the "what" dimensions of instruction. The analysis of "what" dimensions is closest to what has traditionally been subsumed under the rubric "curriculum design". It involves the analysis of the characteristics of different subject matters (e.g., history versus mathematics), the particular structure of one subject (e.g., arithmetic versus topology), as well as general variables such as difficulty levels, step sizes, inherent logics and sequences, hierarchial organization, etc.

A second and very important component of task analysis is the specification of instructional objectives. In fact, task analysis is often taken to be synonymous with this dimension. While there are many differing conceptions of exactly how objectives should be specified, it is generally agreed that they should define the expected behavior of a learner after instruction has occurred. Only if the objectives are clear and explicitly stated is it possible to determine if learning actually occurred and assess how effectively. For this reason, the formulation of objectives for a particular task or subject is crucial to the overall success of instructional design. Task analysis also involves the specification of the skills or abilities which are required by a particular task or subject matter. In order to specify the nature of instruction needed, one must be able to specify what types of abilities (e.g., cognitive, affective, psychomotor) are involved and what levels. Taxonomies of learning outcomes (e.g., Bloom, Gagne) are valuable tools in the identification of levels of skills and abilities.

Learner analysis is concerned with the "who" dimensions of instruction. The analysis of "who" dimensions is necessary because instruction will be different for different types of learners for the same task or subject. A rather broad and encompassing "who" dimension is the pre-entry skills or behavior of the learner. Any instruction makes certain assumptions about the skills and abilities which the student already possesses. Failure to possess these assumed skills will almost certainly prevent the learner from benefiting from the instruction and achieving the desired learning objectives. A fairly simple example involves the understanding of instructions provided for a task. A student who lacks the necessary reading or comprehension ability to understand the instructions clearly cannot progress very far on the task. Because most tasks involve a hierarchial organization of dependent steps, failure to possess the necessary skills will eventually produce inefficient learning.

One major learner analysis dimension is age. Developmental theories (e.g., Piaget, Bruner, Kolberg, Werner) all suggest that the availability of certain abilities and skills is an age- dependent phenomenon. This means that the design of instruction must be arranged with such developmental sequences in mind. It must be determined whether or not the required skills for a task or subject are typically available at the age level of the students. Conversely, the design of instruction should take advantage of the particular skills or abilities available to the learner at a particular age. Things other than abilities change with age also; the nature of motivations, attitudes, curiosity and learning sophistication all change with age.

Another dimension of learner analysis is the population or group characteristics of the learners. This aspect of learner analysis is most evident in the design of instruction for learners with physical or mental handicaps or disabilities. It is also of obvious concern when the instruction is designed to span cultural barriers such as instruction intended for native students. Within any particular population, there are certain subgroups (e.g., poor "inner city" students versus affluent suburban students) with differences in abilities, motivations, attitudes, etc., which will require particular attention.

Individual differences are a well studied (but still poorly understood) dimension of learner analysis. Here we are concerned with differences between individuals which necessitate different instructional methods to produce equally effective learning on the same task. This includes differences in aptitudes, abilities, styles, and personality traits. Since individualized instruction is a major concern of instruction design, a sophisticated knowledge of the ways individuals differ in learning is important.

Means analysis is concerned with the "how" dimensions of instruction. The problem here is to determine what processes or procedures are necessary to teach certain types of learners and tasks. Most of the existing research in means analysis has mostly been devoted to the comparative study of different media. This research has attempted to compare the relative effectiveness of one media over another (e.g., TV versus films) as well as the best ways of utilizing a particular media. The specification of instructional strategies or modes is another major dimension of means analysis. This involves the selection of macrostrategies such as group versus individual instruction or expository (tutorial) versus exploratory (socratic) modes, and microstrategies which include the use of techniques such as shaping, fading, prompting, and so on, within any particular macrostrategy.

Student evaluation is also a major dimension of means analysis. In designing evaluation, a selection must be made between the major types possible (e.g., criterion-referenced, domain-referenced, norm-referenced) in terms of the nature and type of feedback that will best aid the learner. Evaluation will also affect the difficulty, sequence, and step size of the instruction, remedial or enrichment segments, etc. A further dimension of means analysis is motivational variables. Ways of maintaining the interest and attention of the learner must be designed if learning is to take place. Reinforcement theory provides ideas and guidance for maintaining motivation. Humor and novelty are devices also used to maintain motivation. The appropriate "mental set" may facilitate learning, an inappropriate one may inhibit it. Certain means may be used for their motivating properties which enable learning to occur even though they do not directly contribute to learning (e.g., color).

Task, learner and means analysis are the three major aspects of instructional design. However, instructional design (and hence effective learning) is the result of interaction between these three aspects as depicted in Figure 1. Analysis of the task, learner and means dimensions is actually carried out in terms of their interaction; the separation of the dimensions is merely a conceptual one for the purposes of discussion. Thus, one studies the differences in abilities or skills across age so that one can determine what instructional strategies will be optimal for learners of those different ages. One is concerned with the individual and population differences for a certain subject matter so the appropriate motivating conditions can be arranged. Different subject matters may be most effectively presented via certain media, and so on. Instructional design is primarily concerned with understanding the complex interaction of "what", "who" and "how" dimensions to produce effective instruction. This will become clear in the following discussion of the learner, task, and means analyses involved in a program to teach deaf children how to use a ruler.[1]

Learner Analysis

The program was designed for deaf students, aged 10-15, who were in a vocational or pre-vocational stream. The major focus of the learner analysis was on the general capabilities and limitations of deaf students and the particular skills relating to the task of learning to use a ruler.

Previous work using CAI with the handicapped (e.g., Brebner & Hallworth, 1976; Sandals, 1975; Suppes, 1974) suggests:

* the use of concrete examples and minimal abstraction
* strategies which shape behavior rather than those which are didactic
* considerably more use of positive feedback than with normal students

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1. The program was written in COURSEWRITER II and implemented on the IBM 1500 system operated by the Division of Educational Research Services. The 1500 system has 20 student terminals each consisting of a keyboard and CRT display, an image projector, and an audio unit. Each terminal is also equipped with a lightpen which allows the student to respond to questions by pointing to things on the CRT screen.

- feedback messages should be constant rather than variable in nature
- screen displays should be simple and express only one idea per display
- instruction should involve as much student participation as possible

Special considerations for using CAI with the deaf are that the vocabulary and reading demands should be at a Grade 2 or 1 level and that the program should maximize the use of graphics to convey ideas and information.

In terms of the specific skills involved in learning to use a ruler, the minimal competencies which could be expected of all students were identilfed. These were (1) the ability to count sequentially from 1 to 16 and (2) the ability to distinquish line lengths. In addition it was assumed that all students would possess the necessary manual dextermity to hold and use a ruler, pencil, lightpen, and type at the keyboard.

The major individual difference dimension which was allowed for in the program was the degree of computational and spatial abilities. Thus one instructional strategy was designed to utilize counting ability while another involved spatial abilities. The two strategies are described below. The presence of these two strategies allowed for a matching of ability and teaching strategy in the program.

Task Analysis

The overall goal of the program is to teach students how to use a ruler as a necessary skill required in a graphic arts curriculum. The specific terminal objective for the program was that the students would be able to rule up a dimensioned form according to given specifications.

The major competencies in the task are shown in Figure 2. As the Figure shows, the task involves the blending of a set of cognitive skills with psychomotor skills. The cognitive skills involve the discrimination of line lengths, relative spatial positions of the marks on the ruler, learning the concepts of straight and parallel lines, and the rules associated with learning which fractions correspond to which specific marks. Thus, in terms of a taxonomic analysis, the cognitive components involve the skills of discrimination, concepts, and rules. The psychomotor skills required are those involved in holding the ruler and pencil, drawing straight lines, and drawing lines an exact length.

A detailed description of the task objectives in the sequence taught is given in Table 1. The first objective was designed as a connect-the-dot game. The student was presented with an array of numbered dots and instructed to point to the dots in the correct sequential order. This served to determine that the student could count from 0 to 16 in order and also had the necessary manual dexterity to hold and use a pencil accurately. The game format created a high level of interest and motivation towards the program.

The second objective involved the presentation of varying numbers of vertical bars that the student was requested to count. This established that the student would be able to count the number of marks which denoted a particular fractional unit (e.g., 3/4, 9/16, etc.). The shaping in this objective involved presenting the bars wide apart to begin with and gradually making then closer together so that the final discrimination matched the actual discrimination required on a ruler. The third objective involved presenting the student with a number line with 0 to 12 marked on it and asking the student to identify the position of all the numbers (in a random order). The purpose of this exercise was to shape the student up to recognizing the whole units on the ruler without the complications of the fractional units.

The next objective involved learning to distinquish between a straight and non-straight line. The shaping here involved starting with a discrimination between very curved or wobbly lines and progressing to a finer discrimination between lineas which were almost straight. Having mastered the concept of a straight line, the student was then asked to draw some straight lines on paper using a ruler. The next objective presented the student with a ruler on the CRT and asked for the identification of all the unit marks on the ruler (in a random order). After mastering this, the student was then asked to draw lines of various unit lengths and hence combine the skills mastered in the previous objectives.

The following objective presents the student with a number of line segments of different lengths and asks the student to identify the longest and shortest lines. This is a necessary skill in order to be able to distinquish the different fractional marks from each other. The next objective is to actually teach all of the fractional marks in an inch. The instructional strategy used for this is described in detail in the next section. Having mastered the identification of fractional units, the next objective involved having the student draw lines of mixed (unit and fractional) lengths using the ruler.

The next objective involved teaching the student the concept of parallel lines followed by drawing various sets of parallel lines. This step is necessary in order to build the subskill for the final objective which involves drawing up a dimensioned form (consisting of many parallel columns and rows) according to specified dimensions.

The program was designed so that each objective must be mastered before the next objective could be undertaken. The criterion was generally 80% correct except for the objective dealing with the fractional marks in which 100% mastery was required. The reasoning for the setting of these criterion levels was that in a typical test of 5 questions, it is reasonable to expect the student to make one mistake due to carelessness but that 2 or more errors may indicate lack of comprehension or complete learning. The 100% standard for the fractional units was set because this subskill must be perfected to accurately use a ruler. The criteria for the psychomotor objectives involved drawing lines that were straight and within 1/16" accuracy.

With respect to the performance component of the objectives, for most of the cognitive objectives, identification of the correct answer was felt to be appropriate. Thus, being able to identify the correct position on the ruler is the actual nature of the skill required for the task and other response modes (telling, writing, etc.) were inappropriate. Obviously, the most appropriate behavior for the psychomotor objectives was drawing.

Means Analysis

In analyzing the task, an attempt was made to restrict the objectives to only those which were absolutely necessary to achieve the specified terminal objective. Furthermore, in order to minimize the learning demands of the task, a strategy was sought which would involve the simplest types of learning possible. With this in mind, it was decided to use a strategy which would not require the learning of fractions or an understanding of spatial distance. The strategy reflected in the task analysis just described involves learning how to use a ruler on the basis of the length and position of the marks. Thus, the student is taught to associate the denominator of a fractional unit with the length or size of the appropriate mark and the numerator with the position of the mark from the nearest whole inch mark. Using this strategy, the basic cognitive skills needed are the ability to discriminate line lengths and the ability to count -- both of which were considered to be pre-entry skills of the students. This instructional tactic means that it is not necessary to teach the student fractions or spatial partitioning of area which are higher order concepts and principles.

Following this strategy, the student is first introduced to the sixteenth marks and is taught to count every mark starting with the 1/16 mark in order to find the correct 16th mark. Thus, to find the 9/16 mark, the student is told to count 9 marks from the first 16th mark. To find 8th marks, the student must learn to count all the marks as long as or longer than the 8th marks. So to find the 5/8 mark, it is necessary to count the 1/8, 1/4, 3/8, 1/2, and 5/8 marks and none of the 16th marks. The 1/4 and 1/2 marks were also taught this way (although they can simply be memorized). Some screen displays for teaching the 1/8th mark using the counting strategy are shown in Figure 3.

Because there was some doubt that this strategy would work with all students (and allow for those with high spatial ability), a complete sequence for teaching the fractional units on the basis of spatial proportions was programmed as remedial instruction. This sequence would be given if the student failed criterion on the final post-test for the objective on fractional units and also had failed criterion on the post-tests for each individual unit. It involved showing a rectangle partitioned into parts and associating the fractions with the appropriate number of parts shaded in. Next the enlarged inch was shown (same size as the rectangle) and the fractional marks shown to divide the inch into the appropriate number of parts. Screen displays illustrating this strategy for the 1/8th marks are shown in Figure 4. In contrast to the first strategy described above which started with the 1/16 mark and worked up to the 1/2 mark, this strategy started with the 1/2 mark (dividing the inch into 2 parts) and progressed to the 1/16 mark. Although both strategies started with the simplest unit, this was different depending upon whether the strategy involved the "counting" strategy or the "spatial" strategy.

The general instructional logic used in the program is depicted in Figure 5. At the beginning of each objective to be taught, instruction is presented which explains, demonstrates or illustrates the particular skill or concept involved. A post-test follows the instruction which involves the presentation of a problem/question and an indication of the desired mode of response (e.g., typing an answer via the keyboard, pointing with the lightpen, or drawing using a ruler and pencil). The student's response is then evaluated. If the response is correct, a positive feedback message will be given and another question is provided. When the student makes an initial mistake, he/she is prompted for a second try. If the next response is still wrong, an error is recorded and the correct answer is indicated to the student. When all of the available questions/problems have been presented, a test is made to see if the student has achieved the criterion for that objective. If it is met, the student goes on to the next objective. If the criterion is not achieved, remedial instruction is provided if available for that objective or the teacher is called for assistance. Thus the major role of the teacher in this program is not the delivery of instruction but rather the task of diagnosing student problems and providing remedial assistance on an individual basis.

In addition to the general instructional logic outlined, a number of other features were used in the program. In general the teaching of concepts (e.g., straight or parallel line) used the logic of presenting positive and negative instances and emphasizing the discriminating / irrelevant attributes. Directional arrows were used throughout the program as attentional cues or prompts to direct attention to aspects of the ruler or the position of marks. All student response was prompted via capital letters (e.g., TYPE or POINT).

The rate of progress through the program is set by the student as he/she controls the presentation of each successive screen display via the space bar on the keyboard. The sequence of presentation follows the organization of objectives given in Table 1 although a branching feature allowed the teacher to manually override the default sequence in order to skip an objective or review an earlier one.

Implementing and using the program.

While task, learner, and means analysis play their major role in the actual construction of a program, instructional design activity does not stop once the program is completed. In fact, the revision of the program on the basis of student feedback is a crucial part of optimizing the instruction. In the case of CAI, this means studying the detailed performance recordings of all the students for each and every instructional sequence in the program.

A number of changes related to inadequacies of the task analysis were made in the program. The instruction on fractional units was modified so that the post-test for each unit would review all of the previous units not just the most immediate one taught. Thus, the test for the 1/8 marks also included the 1/16 marks and the test for the 1/4 marks included the 1/8 and 1/16 marks. Originally, only the final post-test for the entire unit had tested all of the marks at the same time. This modification reflected a gap in the original task analysis, namely, the skill of integrating or synthesizing each new fractional unit with the preceding units. In fact, the results suggested that this was one of the crucial subskills in the entire task as indicated by the failure of many children to get beyond this step.

Another change to the fractional units involved the inclusion of a "count with me" prompt when the student failed to pick the correct mark in the counting strategy. This involved displaying the message "Count the marks with me" and then pointing to each of the successive marks while also showing the numbers. This demonstrated the correct use of the counting strategy and allowed them to figure out what they had done wrong. Originally, an arrow would have pointed to the correct mark and they would have been told that their selection was "Wrong". The original correction procedure showed them the right answer but did not help them discover what they had done incorrectly.

The last objective was also modified. It was clear that the step size from the objective of drawing parallel lines and that of drawing up a dimensioned form was too large. Instead of asking the students to immediately draw up a page-size dimensioned form, they were asked to draw a series of dimensioned forms beginning with a simple box and working up to more complicated forms. Thus, more shaping was necessary in order to achieve the final objective. In addition, it was necessary to point out to the students that the final dimensioned form would occupy the entire page. This was a minor (but important) aspect which had been overlooked in the original task analysis.

In addition to the changes to the instructional content, a major change was made to the instructional logic. According to the original logic, if a student failed a post-test criterion for an objective, a message was displayed on the screen telling the student to call for the teacher's help. The teacher would watch as the student went through the post-test again and diagnose the problem. It was felt that a single time through each unit provided insufficient practice and also necessitated an excessive demand for teacher assistance. In view of this, the logic was changed so that when a student failed a post-test, they would be branched back to the beginning of the post-test again. If the student failed the post-test on the third attempt, then the message was displayed and teacher assistance called for. The general effect of this change was to increase the amount of drill and practice the student received in the program.

With respect to instructional strategies, it was found that most students had considerable difficulty understanding the counting strategy when it came to the 1/8 marks and they had to learn the rule to count all the marks as long as or longer than the 1/8 marks (but not the shorter marks). Using this rule apparently demanded considerable reasoning ability and hence made the counting strategy much more difficult than we had expected (since it only involved the subskills of counting and discriminating line size). The introduction of this rule was amplified and the student was asked to identify all the lines which were as long as or longer than the 1/8 marks. Although these modifications made the rule easier to learn it became apparent that this step called for reasoning skills which were beyond the capabilities of most of the students...hence a failure in the initial task and learner analysis.

Conclusions

This paper has discussed instructional design considerations of CAI for the deaf as exemplified by a specific program about the use of rulers. Hopefully, the discussion has brought out the nature of task, learner, and means analysis in the context of CAI. The important conclusion to be drawn from all this is that CAI itself possesses no magic which will turn poor teaching into good teaching. It does, however, provide a medium which permits individualized and interactive instruction, exact documentation of instructional strategies and logics used, and detailed monitoring or student performance and this facilitates considerably the design of better instruction.

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REFERENCES

Brebner, A. & Hallworth, H.J. A review of experience with CAI for the developmentally handicapped. _Proceedings of the 2nd Canadian Symposium on Instructional Technology,_ NRC, Quebec, 1976.

Sandals, L.H. Computer assisted learning for the future: Some practical considerations for research, especially with children and adolescents who have handicaps and/or learning problems. _Programmed Learning & Educational Technology_ , 1975, _12(5)_ , 299-305.

Suppes, P. A summary of cognition in handicapped children. _Review of Educational Research_ , 1974, _44_ , 145-176.

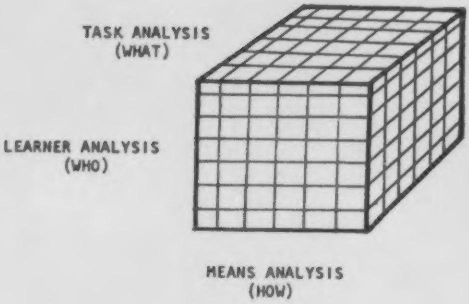
TABLE 1

Instructional Objectives.

CONDITIONS	PERFORMANCE	CRITERIA
1. Given a series of dots numbered from 0 to 16 on the screen	Using light pen, points to the dots in successive order	Each dot constitutes one trial. No more than 3 errors for all 16 trials
2. Given a series of vertical bars in sets of 1 to 16 on the screen	Counts the number of bars and types in the answer	4/5 Correct
3. Given the numbers from 0 to 16 in random order and a linear scale with 12 equally spaced numbered intervals on the screen	Using the lightpen, points to the correct position on the numbered scale	10/13 Correct
4. Shown a series of straight and curved lines in pairs with the discrimination becoming more difficult for each pair	Using the lightpen, points to the straight line in each pair	4/5 Correct
5. Given illustrations of the correct way to hold and position the ruler, pencil, and paper, and using a pencil and ruler	Draws straight lines between indicated crosses (x) on paper	7/8 Correct
6. Given display of standard ruler on the screen	Using lightpen, points to the whole inch marks	4/5 Correct
7. Given instruction on the screen about how to draw measured line lengths and pencil and ruler	Draws lines of whole inch lengths always starting at the 0 mark	4/5 Correct
8. Given a series of line segments of different lengths on the screen	Using lightpen, points to the shortest and longest line segments	2/2 Correct
9. Given instruction on finding 1/2, 1/4, 1/8 and 1/16 marks on ruler and enlarged 1 inch portion of ruler on screen	Using lightpen, points to all fractional marks	100% mastery. Must be with 1/16"
10. Given instruction about combining whole and fractional marks and display of full ruler	Using lightpen, points to correct mark	4/5 Correct
11. Given ruler and pencil and directions on screen	Draws lines of mixed fractional lengths	13/16 trials correct with 1/16" accuracy
12. Given a series of parallel and non-parallel lines in pairs and instructions on the screen	Indicates (by typing yes or no) whether pairs of lines are parallel	4/5 Correct
13. Given instruction on how to draw parallel lines via illustrations and pencil, ruler and paper	Draws parallel lines a specified distance apart	3/4 Correct with 1/16" accuracy
14. Given instructions on the screen, a dimensioned sketch, and pencil, paper, and ruler	Draws a dimensioned form according to specifications	Each line is 1 trial, Form consists of 8 lines 7/8 trials correct with 1/16" accuracy

FIGURE 1

MAJOR DIMENSIONS OF INSTRUCTIONAL DESIGN


TASK ANALYSIS
(WHAT)
LEARNER ANALYSIS
(WHO)
MEANS ANALYSIS
(HOW)

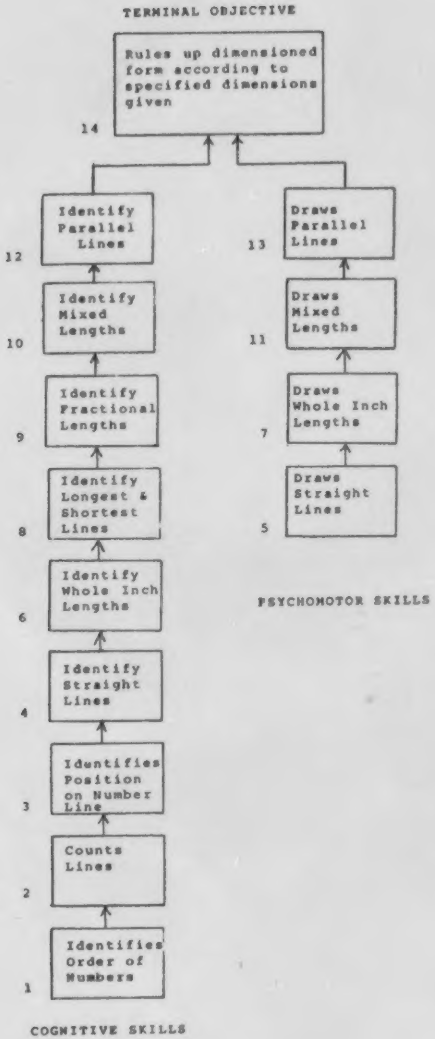

TERMINAL OBJECTIVE
Rules up dimensioned form according to specified dimensions given
14
Identify Parallel Lines
12
Draws Parallel Lines
13
Identify Mixed Lengths
10
Draws Mixed Lengths
11
Identify Fractional Lengths
9
Draws Whole Inch Lengths
7
Identify Longest & Shortest Lines
8
Draws Straight Lines
5
Identify Whole Inch Lengths
6
PSYCHOMOTOR SKILLS
Identify Straight Lines
4
Identifies Position on Number Line
3
Counts Lines
2
Identifies Order of Numbers
1
COGNITIVE SKILLS

Figure 2. Competencies required by task.

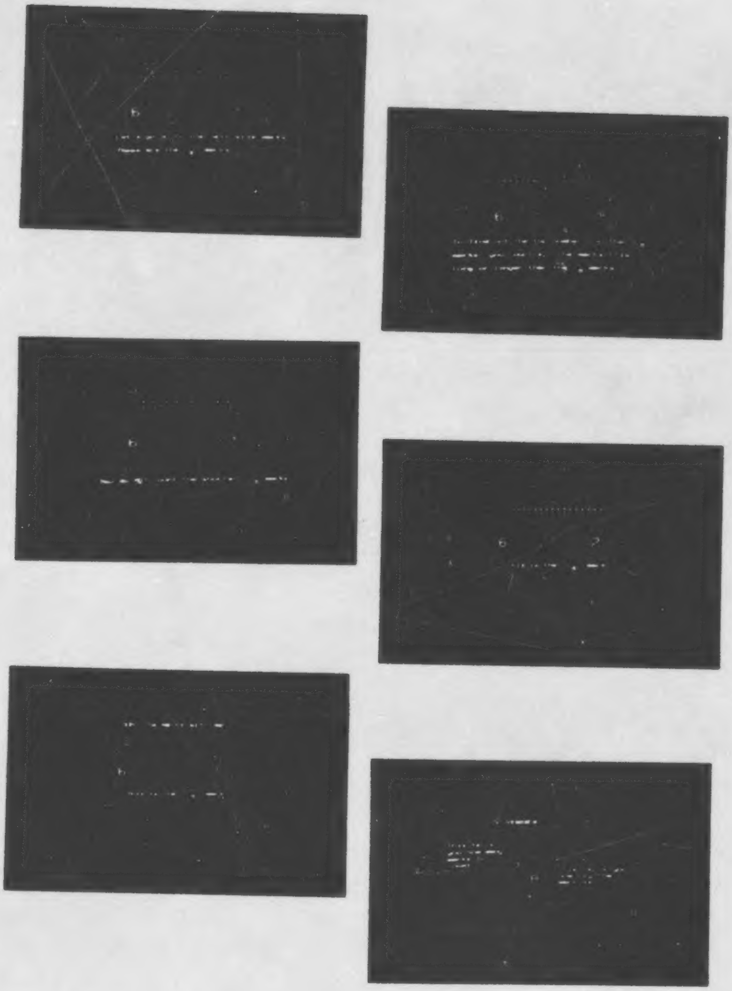


Figure 3. Screen displays for teaching the 1/8 mark using the counting strategy.

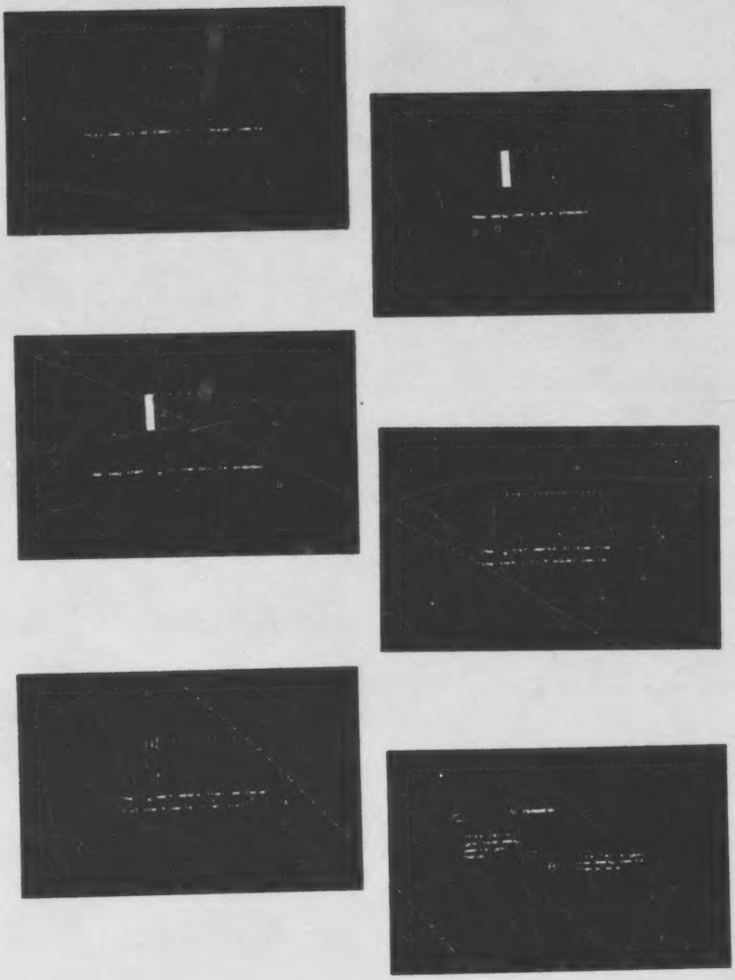


Figure 4. Screen displays for teaching the 1/8 mark using the spatial strategy.

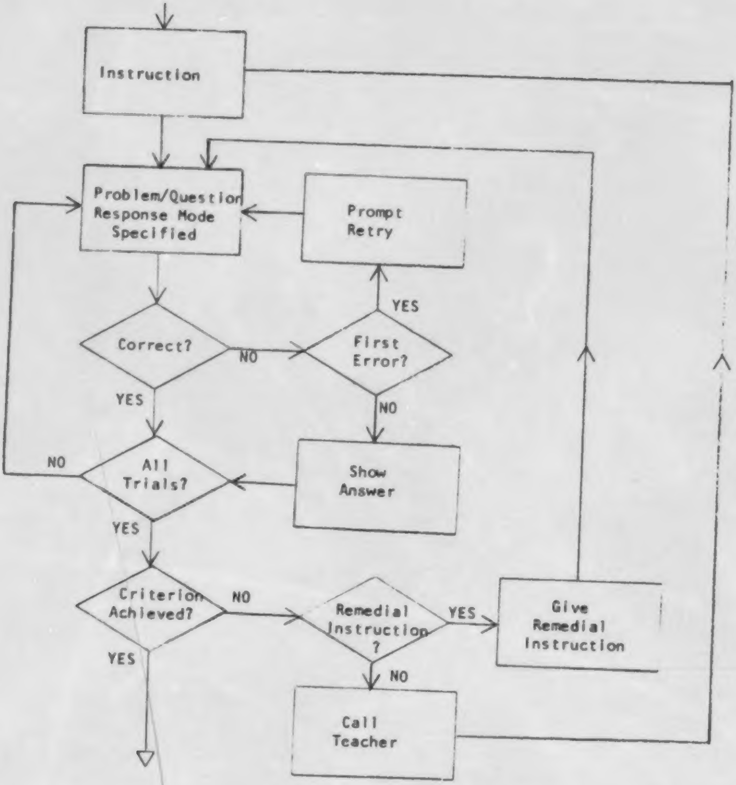

Instruction
Problem/Question Response Mode Specified
Prompt Retry
Correct?
NO
YES
First Error?
YES
NO
All Trials?
NO
YES
Show Answer
Criterion Achieved?
NO
YES
Remedial Instruction ?
YES
NO
Give Remedial Instruction
Call Teacher

FIGURE 5. General Instructional Strategy Used in Program.

THE ROLE OF CAI AND VIDEO TAPES AS INSTRUCTIONAL SUPPLEMENTS TO AN ENGLISH LANGUAGE PROGRAM FOR THE HEARING IMPAIRED

By: James L. Madachy and
J. Douglas Miller

The information included in this paper represents our experience during the past three and one half years in creating and using CAI and video tapes as methods for improving the English language skills of the hearing impaired. The paper divides into 2 main parts: the first part discusses CAI as a working system within a total English language program. The second part discusses efforts to integrate CAI with video tapes as a means of increasing the effectiveness of English language instruction for hearing-impaired students.

We have presented information about Gallaudet's Language CAI system elsewhere; however, a bit of background is perhaps necessary before we discuss our newest developments. Gallaudet has a DEC 1040 computer which is linked to the English department's 10 CRT terminals. We have an interactive system of 200 lessons based on an English-as-a-Second-Language format. Our system has been in use for two and one-half years now by approximately 350 students each semester. The lessons have proven to be very effective in savings of teacher time and in student advances in knowledge of English structure. Our core structured lessons proceed from the "to be" verb to complex clausal relationships, but we have added several supplementary areas which we are very excited about in terms of a total English language program.

Our first priority was to randomize our core lessons. We completed this with the assistance of Kevin Casey, the director of our computer division, who rewrote our user's program so that the computer could generate a randomized version of each lesson as it is presented to the student. Each lesson now has three to five examples of each task so that no two students get the same lesson. For example, if we had a lesson which had 30 drill and practice tasks to be performed, we added four more examples of each specific task so that now the computer choses among 150 examples but still presents only 30 to the student. Our lessons are set up in such a way that each task is considered a unit; the random selection is one out of the four or five included in that unit instead of selecting any 30 tasks from a base of 150. In this way we are able to make sure that each specific lesson is comparable to any other randomized unit of the same number. The level of difficulty and the skill involved are maintained regardless of which tasks are selected for any one lesson.

Because of the randomized factor in the lessons, now a student can repeat a lesson numerous times without becoming bored by seeing the same examples and without subconsciously memorizing the correct answers. We originally used CRT's to prevent cheating by students who would possibly give a hard copy of the correct answers to a friend. Now, we can permit the use of hard copy terminals with the concomitant advantage of the student's being able to retain a copy of the lesson for subsequent study. Each of the lessons still has a pre-test, explanations, examples, and hints leading toward a correct response. Only the individual tasks are randomized.

Because we feel that CAI can be used for more than just structural drill and practice, we have begun work in other language areas. It is obvious that simply using CAI consists of constant reading practice; however, we decided to try a more formalized type of reading instruction through CAI. We based our lessons on six general reading skills (reading for sequencing, detail, main idea, inference, contextual clues, and drawing conclusions). Each lesson consists of 20 short paragraphs after which a question is asked. Because we have limited the possible responses to four, we were able to respond specifically to all possible erroneous responses, thus leading the student toward the correct response rather than simply providing the right answer.

We designed the paragraphs and the hints in such a way that if a student makes a mistake, we were able to indicate what part of the paragraph or what word the student has most likely not focused in on. For example, we can tell the student to re-read a given sentence if the answer is embedded in that sentence, or we can define a word if that word is the key to a proper response. To prevent boredom, we vary the skill involved in reading each paragraph, but we did emphasize one skill in each lesson by having ten of the twenty paragraphs focus on one specific skill. We decided to use skill-based reading work because we feel that our students must work in a step-by-step building process in reading just as they do in structure work. If a student can learn how to read for detail, then move to sequencing and reading for the main idea, then we can move him to the most difficult areas of reading for inference and drawing conclusions. We must first make sure he is understanding the facts and vocabulary of what he reads before we demand that he use the additional cognitive processes required in drawing conclusions.

The teaching of reading is a skill that so few people understand that we are content for now to give hints about how to read and to draw the student from simple to more complex skills. We feel that the key to valid CAI reading practice is in the careful creation of reading materials that can be controlled sufficiently to permit meaningful hints. If a passage has so many problem areas in it that we cannot tell where the student is likely to go wrong, we cannot write adequate hints. We feel that much more work in the area of reading through CAI is necessary and possible. This is a sadly neglected part of CAI materials available on the market.

Another possible area well suited to CAI is that of vocabulary development. With all areas using CAI, but especially with reading and vocabulary, we wish to emphasize that all computer work is done within the larger context of our total language program. We never put a student solely on computer work. We use supplementary materials whenever possible, and most often the computer is simply a supplementary or alternative material.

We now use several different types of vocabulary drill in our CAI package. We have designed lessons specifically with a deaf population in mind, but they can be used with any other group. We now have five lessons on prefix-suffix drill. We choose the most common prefixes and suffixes and a small number of crucial root words for our drills. We have ten lessons on the most common idiomatic verb phrases, which we feel is an area of real need for hearing-impaired learners. In these lessons, definition for the idioms are given and the student is asked to choose the proper idiom as used in context. We chose eight lessons in which we supply definitions for words, and then the student must use the proper word in a complete sentence. We have seven lessons in which the student must also type a complete sentence, but these words are supplemented by video-tape presentations using ASL, signed English, and captions. Each word is used in four different sentences.

Our newest vocabulary lessons are short answer drills. These are best described as a combination of test and practice. We do not supply definitions, therefore, students are being tested on their past knowledge of the word, but we do permit two tries and then give the correct answer, so the student is being given practice. There are twenty-five words in each lesson, each word being presented twice. In addition to these quick answer vocabulary drills, we have created four experimental lessons in PILOT. These lessons are totally contextual. We tried to couch the vocabulary choices in sentences with sufficient clues so that the student can grasp most meanings from context. These are also quick answer drills with hints leading toward the correct response. We used PILOT instead of GNOSIS for these lessons in order to reduce the need for carriage returns and to permit a greater range of responses. PILOT is also compatable with a greater variety of computers. Included in our handouts you can see a sample of the differences in appearance between a GNOSIS and a PILOT program. The PILOT lessons have a much cleaner appearance; however, they are more time consuming to program.

As we mentioned earlier in this paper, we use CAI as a supplementary resource to the other materials in our total English language program. Video tapes are included among the English language materials we are now developing, and the integration of video tapes with CAI would seem to offer definite advantages over using either medium alone.

Despite the many benefits inherent in CAI, it has at least one limitation as a language-learning device. That is, the language-related tasks that students perform via CAI tend to become ends in themselves. Completing language-related tasks is not always synonymous with language learning in its broader application. Students using CAI do show general improvement in English language work; however, we know of students who perform admirably at the computer terminal but whose English language skills continue to be deficient in more ordinary communication situations. When exposed to controlled situations such as CAI, students can often learn to manipulate English language structures successfully. However, the same students often misuse those same structures when asked to write a letter or an essay. It would seem that such students have not internalized the concepts embedded in the English language structures they have practiced at the computer terminal.

It would seem that students could profit from using materials which would help them master both the language concept and the corresponding form or structure which communicates that concept. Using video tapes and CAI as instructional complements would seem to be of definite value in this regard. Video tapes would seem to be a natural medium for presenting and illustrating certain language concepts; CAI would seem to be an excellent device for providing drill and practice in manipulating various English language structure.

In view of this dual purpose, we have completed an experimental project in the active voice and the passive voice. We selected the passive voice because the past participle is a structure difficult for many hearing impaired students. Moreover, the idea of "doer" and "receiver" embedded in these structures seemed to be appropriate for visual presentation. The project attempts to integrate video tape instruction of these structures with CAI. In completing this learning unit, the student proceeds throught the following steps:

I. Students complete a video tape pre-test on the active and passive voice, simple past tense. If students fail the pre-test, they proceed to step II.

II. Students receive CAI drill and practice in forming the simple past tense of regular and irregular verbs.

III. Students receive CAI drill and practice in forming the active voice, simple past tense.

IV. Students receive video instruction and practice in forming the active voice, simple past tense.

V. Students receive CAI drill and practice in forming past participles of regular and irregular verbs (forming past participles correctly is necessary to forming the passive voice).

VI. Students receive CAI drill and practice in forming the passive voice, simple past tense.

VII. Students receive CAI drill and practice in transforming the active voice to passive voice and vice versa, simple past tense.

VIII. Students receive video instruction in the passive voice, simple past tense.

IX. Students complete a video[1] tape post-test in the active and passive voice, simple past tense.

Aside from the pre-test and post-test segments, students can access the computer lessons and the corresponding video tape materials without the aid of the instructor. Once given the lesson numbers, students use standard procedures to logon to the computer and they use a conventional video cassette player to access the video tapes. Students receive CAI drill and practice in using appropriate language structures before viewing the video sequences dealing with those same structures. The reason for this arrangement is that we wanted to make sure that students were familiar with the language structures before asking them to use those structures in responding on paper to video-taped scenes. The computer materials give instruction in verb formation and in active and passive constructions. The video segments offer instruction in the active and passive voice by means of sign language, captions, and short skits. Students have practice in associating the language structures with the corresponding concepts by viewing various video-taped scenes and then using either the active voice or the passive voice (whichever is indicated) to describe the action occurring in each scene.

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[1] These steps were mentioned at a paper given at the ADCIS convention in Santa Barbara (January, 1976); however, the project was not completed at that time.

This CAI/Video tape unit has been used with approximately fifty students. Students have shown a marked improvement in post-test scores compared with pre-test scores. However, other ways of testing the materials need to be used and documented. The video tape materials thus far completed deal with the active and passive forms of fairly simple verbs (both regular and irregular verbs) such as bite, eat, drink, throw, hit. New materials will introduce more sophisticated vocabulary items and will give the appropriate, idiomatic structures (either active or passive) for using these vocabulary items. Because hearing-impaired students have difficulties using participles correctly, we hope to eventually create CAI/Video tape materials which will teach verbs included in the following paradigm:

The man frightened Mary.
Mary was frightened by the man.
Mary was a frightened girl.
The man was frightening.
He was a frightening man.

The computer and video materials described in this paper represent alternative and supplementary ways to help improve the English language skills of the hearing impaired. As used at Gallaudet College, they are but a part of a total English language program. Although some testing of these materials has been completed, the relationship between student exposure to these materials and overall improvement in English language skills needs to be researched and documented.

Description of a Computer-Based, Interactive, Instructional Television System Prototype

by

James R. vonFeldt

April 21, 1977

NATIONAL TECHNICAL INSTITUTE FOR THE DEAF
ROCHESTER INSTITUTE OF TECHNOLOGY

We believe that an interactive, random access device which can provide the elements of computer-assisted instruction and instructional television will provide instructional gains for concepts requiring motion that cannot be done currently by another means. Since no such system exists we have set out to design, build and test a prototype.

Questions To Be Addressed

1. Is it possible to build a system which incorporates the elements of interactive CAI and instructional television for use in a learning center?

2. What is the learning effect of such a system (if it is possible)?

3. Can such a system be used as a research instrument?

Rationale

There are several factors which have led us to conclude that this prototype should be built and tested.

1. Significant instructional gains have been documented as a result of drill and practice provided through interactive, individualized computer-assisted instruction.

2. Significant reductions in student time required to reach mastery have occurred through using CAI.

3. Instructional television is an excellent media to portray motion with audio.

4. Television replay systems have the potential for controlled redundancy through random access.

5. Individual needs can be diagnosed and provided by combining elements of CAI.

6. Computer based management and research capacity can be employed as instruction progresses.

The Two Elements: TV and CAI

A) Television

Television, with its simultaneous audio capacity is an excellent way of representing concepts which require movement. The subtle flow of action can be shown in real time highlighted in color. TV can provide these critical visual experiences in portable form by using cassettes or cartridge. When motion is critical, training must occur with the real experience or with a televised representation. In many cases TV is more practical and lower cost than teaching under "real" circumstances.

B) Computer-Assisted Instruction

Interaction, data collection, diagnosis, prescription and reinforcement describe CAI. Unique individualized instruction is tailored for each student. Sufficient practice provides skills at mastery level. Since the computer is the media upon which CAI is based, related capacities can be employed such as student performance summaries and course evaluation. The computer can also be a controller of other media such as a VTR (Video Tape Replay).

Combined CAI and TV

Combining the elements of CAI and TV should provide a new dimension of instructional possibilities. TV would be enriched by the process of interaction making it an "active" learning experience. CAI will be enriched as the information presentation will be expanded to include motion with simultaneous audio. This new system will include all of the computer-based capacities for individualizing instruction, student performance recording and research. It will include all television capacities with controlled random access. The prototype will also include special features which will allow research of specific variables.

Computer-Assisted Instruction/Instructional Television Prototype

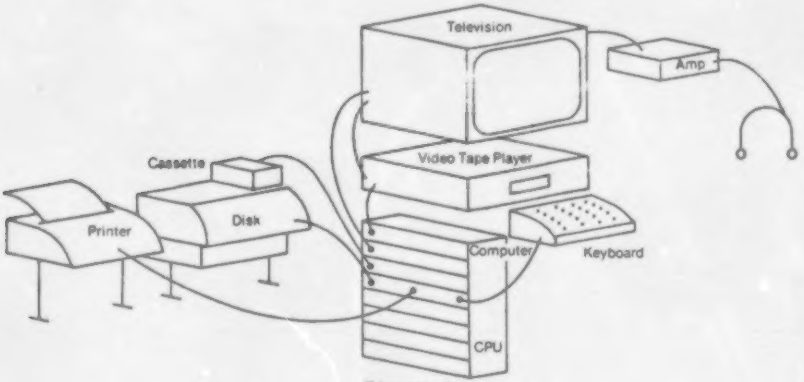

Figure 1

Instructional Use

Instructional demands in a learning center require that the prototype demonstrate reliability as well as the ability to provide instruction. A projected instructional event would include the following sequence of activities:

1. A student sits down at a learning station including keyboard, Color TV and VTR (see figure 1).
2. The student signs onto a lesson which has been assigned by a teacher.
3. Information about the unit of instruction and which TV tape to load is displayed on the TV set.
4. The student begins the lesson. A pretest sequence (motion with audio) is given followed by tutorial or appropriate drill; i.e., CAI is interspersed with Motion/Audio.
5. The student responds to questions.
6. The computer analyzes the student's response and based on performance he will be given a unique set of instructions with immediate feedback.

7. Student control of review, problem solving practice and quiz-taking would follow a unit but precede a proof section (posttest).

8. Non mastery of the posttest would again formulate an individualized set of instruction based on the student's responses. Reaching mastery would automatically exit the student from the lesson. Scores would be presented to the student.

9. Student data is collected as he goes through the course. Summaries of the student's progress (pretest scores, quiz scores, completion, etc.) would be available upon demand by the student's teacher. The days the student was on the program and time used will be included.

10. A summary of all of the class data will be available.

11. A summary of student's paths and other data will be available to evaluate the effectiveness of the courseware (programmed instruction).

Research Use

Research use of the prototype can focus on several different problems such as instructional stimuli variables, student learning characteristics or perhaps formative and summative course evaluation. To be effective as a tool for research, various display capacities of the CAI/TV system must be controlled. Examples:

1. video with simultaneous audio
2. video without audio
3. audio without video
4. random access to video segments
5. CAI display and interactive capacity

The inclusion of "interactiveness", random access and other features of this system will allow research into the effectiveness of instructional TV production and individualized CAI strategies to mention but two.

Summary

Creation of a computer-based interactive television system appears to have strong potential for instruction demanding motion and individualized instruction. If upon creation it does prove to have significant effect many questions will be raised. Some questions would be: "How does effective development occur? What TV production techniques are most effective and efficient? And, what CAI production techniques are most effective and efficient?

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A PROJECT IN AURAL INTERVAL IDENTIFICATION, PHASE ONE

by

Marvin S. Thostenson

Most musicians will agree that a thorough knowledge of intervals is an important facet of training for music students. This project deals with one aspect, the aural identification of intervals by a sample that totals 613 students. The data for this first phase includes the administration of the aural skills tests to 160 University of Iowa students in the fall of 1976, to the 142 continuing in the spring of 1977 and to 165 students from five other schools in the spring of 1977. For some details data from two earlier University of Iowa classes with 146 students is used.

I. Background Information.

Musical pitch divides into octaves that divide into 12 half-steps. These combine to form 12 discrete sound distances called intervals. Each one can be identified by its symbol-name, such as minor second (m2), or it can be written in music notation, given one note. In this project each interval heard is identified by symbol-name. Aural identification is necessary in three performance modes, namely, upward, downward and simultaneous.

Errors in identifying intervals occur for several reasons. A student may have developed an incorrect association between an interval sound and its symbol-name. A distraction such as thinking about the last item heard may have persisted to fog the memory, or, the student may not yet have any distinct aural interval image in his memory. The result is that an interval is incorrectly identified using another interval's name, thus causing a confusion. There are 132 such confusions possible using only the basic major, minor, perfect and tritone interval names. Lack of previous systematic training in this area is obvious with a rather large proportion of music students, especially in the first year, but hearing deficiencies continue to persist to lesser degrees in more advanced classes.

II. Purpose.

The ultimate goal of this project is to improve student accuracy in hearing the several interval sounds, with the subsequent hope of improving perception of the pitch factor in music. Correlative is the goal of completing the basic aural interval training more quickly, ultimately, perhaps, in one semester. This would permit a broader development of musicality during the four semester sequence normally allotted to aural skills programs.

The above mentioned goals have a logical chance of becoming possible through the development of a systematic, efficient and reliable methodology for improving the aural perception of intervals. It seems reasonable to accomplish this by utilizing the results of research to devise carefully constructed remedial training procedures or programs to lessen the number of errors usually involved in the most error-prone confusions. Studies of this type are ideally suited to the capabilities available in computer assisted instruction. The present project does not include data from any school that was then benefitting from the use of C.A.I., but some comparisons are made with the results achieved by one small sample that was intensively tested in their identification of aural intervals and triads.[1] A final hope is that the information made available in this project may possibly provide some impetus for further research in this area, both through and independent of C.A.I. facilities.

III. Brief Review of Selected Research.

There has been considerable research in the area of pitch, especially as related to the measurement of achievement and also the estimation of musical talent. However, that dealing directly with the perception of intervals is

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limited, although a number of studies touch on the topic tangentially. One who developed a useful interval discrimination test, Madison (1942)[2], sets the proper philosophical tone by stating that "interval quality lies at the very root of our system of tonality or of atonality for that matter." In his tests each item is constructed in a four-foil multiple-choice format, in which the student hears four intervals played. The correct response is to hear which of the four sounded intervals sounds unique; the other three are a single contrasting interval heard at three different pitch levels. Ortmann(1934)[3], Lundin(1949)[4] and Ottman(1956)[5] were able to show that significant relationships exist between interval perception and the aural music skills of sight singing and music dictation. Hutton, Barnes and Bolden have done research in methodology involving the pitch factor. Hutton (1953)[6] found that use of a flash card technique for drilling pitch patterns raised the sight singing scores of selected fourth grade pupils. Barnes (1960)[7] showed that interval hearing was important, but also noted that contextual influence was an inhibiting factor requiring consideration in teaching sight singing. Bolden (1967)[8] compared three methods for improving sight singing and concluded that none among extensive class use of the piano keyboard, the recorder, syllables, or letter names was significantly better. However, the use of either syllable or letter names yielded somewhat higher scores in the pitch area. Three other researchers, Ritchie, Marquis, and Cooper, discussed the effect of context upon perception and performance of the interval content of melodic examples. Ritchie (1960)[9] found that the harmonic content of a phrase often inhibited the recognition of melodic pitches, except when the harmonic structure agreed with the melodic line in an obvious manner. In comparing the singing of isolated intervals with intervals within a melodic context Marquis (1963)[10] found that rhythmic position, scale position, and the harmonic implications were considerations affecting the perception and performance of melodic intervals. Cooper (1965)[11] built a sight singing test that revealed differing levels of difficulty for intervals occurring in the various contextual situations found in his test.

A recent project, that of Killam, Lorton and Schubert (1975)[1], is quite directly applicable to the present project. This study dealt intensively with a sample of 15 students using the C.A.I. facilities at Stanford University. Several points from this study provide interesting comparisons with the present study.

IV. Testing and Analysis -- University of Iowa Samples

Three different tests were used primarily in this project, namely, Tests #3, #4, and #5. To a lesser extent information derived from use of two earlier tests (#1 and #2) was of value. Each test had a separate section for each performance mode -- upward, downward, and simultaneous. The 108 items were comprised of three 36-item sections, each one including three examples of each basic interval, namely, the m2, M2, m3, M3, P4, tt, P5, m6, M6, m7, M7, and P8. Tests #2 and #4 had only one example of each interval, giving them three sections of 12 items each. All the tests utilized selected pitches from the F just below the bass clef to the D above the second ledger line above the treble clef. This gamut of three octaves and a major sixth falls well within the vocal range. The above information is presented in more detail in Table I on the following page.

The data provided by the three 1976-1977 first-year samples using Tests #3, #4, and #5 was analyzed to reveal the interval errors and the accompanying confusions generated. This brought out that 40 upward, 49 downward, and 55 simultaneous interval confusions accumulated enough errors to be considered significant. Significance for this project was determined in a practical manner. Each sample was tallied by scores from high to low and then the

Table I

Interval Testing, University of Iowa Samples

Sample	Size	When Tested	Test	Upward	Downward	Simult's	Total Sample
1st yr.	85	Fall,1974	#1	36 items	36 items	36 items	108 items
1st yr	61	Spring,1976	#2	12 items	12 items	12 items	36 items
1st yr.	95	Fall,1976	#3	36 items	36 items	36 items	108 items
1st yr.	83	Dec.,1976	#4	12 items	12 items	12 items	36 items
1st yr.	80	Spring,1977	#5	36 items	36 items	36 items	108 items
2nd yr.	65	Fall,1976	#3	36 items	36 items	36 items	108 items
2nd yr.	65	Dec.,1976	#4	12 items	12 items	12 items	36 items
2nd yr.	65	Spring,1976	#5	36 items	36 items	36 items	108 items

the papers were divided into five equal or nearly equal quintile sections -- top, upper middle, middle, lower middle, and low. Thus, in a class of 75 to 100 pupils (or in such a grouping) each quintile would contain from 15 to 20 papers representing that number of students. Interval confusions with but one or two errors were considered to be random but a cluster of 3 or more errors was considered significant since it suggested an error level of about 15 to 20% at any particular quintile level. The number of confusions, significant or otherwise, and the associated errors in each mode are shown in Table II. These results derive from the first year sample shown to be taking Tests #3, #4, and #5 in Table I, above.

Table II

Interval Tests, 1st yr., SUI, Errors and Confusions

Mode used	Total errors	Total conf's	Signif. errors	Signif. conf's	% of total error included
upward	633	64	576	40	91.0 %
downward	879	88	795	49	90.4 %
simult's	962	102	833	55	86.7 %
Totals	2474	144	2204	144	89.1 %

The total of 252 confusions of which 144 were significant included 82 separate confusions from the 132 possible. Among these 82 twelve pairs were significant in both directions, thus setting apart a set of 24 confusions that were common to all three modes of performance. These 24 interval confusions represented only 29.3% of the 82 different confusions but accounted for 53.3% of all the errors made in the three modes of performance (1323 errors of the total of 2474). See the listing in Table III.

Table III.

Twelve Double Pairs of Interval Confusions

Double Pairs	One confusion *	Another confusion *
m2; M2	m2/M2	M2/m2
m3; M3	m3/M3	M3/m3
P4; P5	P4/P5	P5/P4
tt; m3	tt/m3	m3/tt
tt; m7	tt/m7	m7/tt
P5; M3	P5/M3	M3/P5
m6; M6	m6/M6	M6/m6
m7; M7	m7/M7	M7/m7
P8; P5	P8/P5	P5/P8
P4; m3	P4/m3	m3/P4
m6; m7	m6/m7	m7/m6
M7; tt	M7/tt	tt/M7

* m2/M2 is read as "A minor 2nd is heard as a major 2nd", etc.

The remainder of the confusions encountered were classified in three ways. For each mode of performance several more two-way interval pairs were found to be significant in relation to at least one but never all three modes. Another group of confusions significant only in one direction were likewise significant to at least one mode of performance. The last group consisted of the confusions and errors considered to be non-significant.

V. Statistics -- University of Iowa, First and Second Year Samples

The statistical data for the SUI first-year class on Tests #3-#5 are shown in Table IV. Even though the median in each performance mode is 30 or higher, there was much wider dispersion in the low one-half of the scores resulting in high reliability in each section. In the short test, #4, only the simultaneous section of 12 items gave evidence of reliability (and conversely deficiency in their auditory recognition). However, it becomes obvious at the end of the second semester that only upward intervals have been well learned as one notes by examining the data for Test #5.

Table IV.

Statistical Data, SUI, 1st-yr., Fall '76, Dec., '76, Spring '77

Class	N	Mode	Items	Median	Mean	St.Dev.	Rel'y
Fall 1976, 1st yr.	95	up	36, Test #3	32.12	29.97	7.45	.96
		down	36, Test #3	31.66	29.09	8.96	.95
		sim's	36, Test #3	30.00	28.52	10.50	.96
Dec. 1976, 1st yr.	83	up	12, Test #4	12.00	11.23	1.64	-----
		down	12, Test #4	11.00	10.78	2.80	-----
		sim's	12, Test #4	10.97	9.70	2.74	.80
Spring 1977, 1st yr.	80	up	36, Test #5	34.32	33.21	3.5	.66
		down	36, Test #5	33.50	31.22	5.9	.88
		sim's	36, Test #5	31.2	31.6	6.4	.91

Since first year students are prone to make the most errors in aural interval identification it was felt wise to check first and second year data as to statistics, interval errors and interval confusions. The second year class took the same series of three interval tests (#3, #4, and #5) but under less favorable circumstances. The first long test, #3, was given during the first two weeks of the semester, thus relying heavily on the training recieved during the previous year. After this first testing almost no class time was given to interval identification as such, but low scoring students were encouraged to do work in the Aural Skills Laboratory (using ordinary taped practice materials). These factors may account in part for the small differences that exist in the comparative scores of the first and second year class. Only in the first upward interval test, #3 in the fall of 1976, is the difference in means actually significant. Since both classes included a number of high or perfect scores it follows that the differences that did exist quite likely resulted from (1) the attrition of some low scoring first-year students, and (2) the improvements made by a number of previously lower scoring students. The data for the SUI second year class is given in Table V, which will make it possible to compare the two classes.

Table V.

Statistical Data, SUI, 2nd yr., Fall '76, Dec., '76, Spring '77

Class	N	Mode	Items	Median	Mean	St.Dev.	Rel'y.
Fall 1976, 2nd yr.	65	up	36, Test #3	35.27	32.95	4.66	.91
		down	36, Test #3	33.36	31.14	6.10	.90
		sim's	36, Test #3	32.17	30.06	6.67	.91
Dec. 1976 2nd yr.	62	up	12, Test #4	12.00	11.37	1.32	-----
		down	12, Test #4	12.00	10.98	1.[illegible]6	-----
		sim's	12, Test #4	12.00	10.18	2.2[illegible]	-----
Spring 1977, 2nd yr.	63	up	36, Test #5	35.3	34.1	2.92	.74
		down	36, Test #5	34.5	32.6	4.93	.86
		sim's	36, Test #5	33.5	31.4	5.52	.88

VI. Confusion Analysis -- University of Iowa, First and Second Year Samples

Analysis of the data from the second year class showed that 72 confusions existed, of which 43 confusions involving 573 errors were yet significant at the end of the second year of training. As a matter of consistency it is noteworthy that 38 of these 43 significant confusions were included with the 54 confusions found significant in the first year sample and through this commonality accounted for 553, or 96% of all the errors made. In the upward mode 21 significant confusions with 170 errors were found; of these 20 confusions including 167 errors were common with the set of 54 first year confusions, and thereby accounted for 96% of the upward errors. The 33 significant confusions of the downward mode included 30 common with the set of 54, covering 232 or 95% of all downward errors. The simultaneous mode included 18 confusions, all of which were common with the set of 54 and therefore accounted for all the simultaneous errors.

In as much as the set of 54 first year confusions includes all confusions that were significant at the first year level and that 38 of the 43 significant second year confusions representing 96% of the errors made are common with the 54 set suggests a strong persistence among these interval hearing confusions. It seems logical to infer that these 54 interval confusions exhibit a high degree of resistance to learning. Reducing the set of 54 to a more concentrated form, using eleven of the twelve two-way all-modes confusions (less the P4/M3 pair), three two-way selectively-modal confusions (tt/m6, M7/m6, and M6/P5) and two one-way confusions (m2/M7 and M2/M3) for a total of 30 basic confusions yields interesting results, as shown in Table VI.

Table VI.

Comparing Confusions and Errors: Sets of 54 and 30 Confusions

	12 two-way - all 3 modes	12 two-way - not 3 modes	6 one-way - not 3 modes	Set of 54 confusions	11 two-way - all 3 modes	3 two-way - not 3 modes	2 one-way - not 3 modes	Basic set of 30 confusions
Con's-	24	24	6	54	22	6	2	30
Err's-	2215	496	155	2866	2170	216	86	2472
% of 54 set -	100%	100%	100%	100%	96%	44%	55%	85%

The fact that the 30 most significant confusions account for 85% of the errors and that conversely the other 24 confusions account for only 15% of all the errors is possibly worth remembering. Table VII gives a listing of both the Set of 54 and the Basic Set of 30.

Table VII.

Listing of the Set of 54 and the Set of 30 Confusions

	Set of 54	Set of 30
Twelve two-way confusions -		
-- 24 in "54" and 11 in "30" are problems in all performance modes. ---	~~M7/tt M7/m7~~ m6/m7 P5/P4 m3/M3 tt/m7 m6/M6 m2/M2 P5/M3 P8/P5 tt/m3 P4/M3	~~M7/tt M7/m7~~ m6/m7 P5/P4 m3/M3 tt/m7 m6/M6 m2/M2 P5/M3 P8/P5 tt/m3
-- 24 in "54" and 3 in "30" are problems in certain perf'e modes. ----	tt/m6 M7/m6 M6/P5 m6/P5 M6/m3 m6/M3 M6/M7 M6/m7 M6/M3 m6/m3 tt/P4 P4/m3	tt/m6 M7/m6 M6/P5
Six one-way confusions -		
-- 6 in "54" and 2 in "30" are problems in certain perf'e modes. -----	m6/P4 M6/tt tt/P5 M2/m3 M2/M3 m3/P5	m6/P4 tt/P5

VII. Statistical Data -- Other Schools

Each of the five other schools cooperating in this project gave one test to their students, Test #5 consisting of 108 items with 36 intervals in each of the three performance modes. It can be assumed that the test administration was similar for all schools involved since all taking part followed the same instructions (as reviewed previously). Since the number of students involved is 165, with 150 first year and 15 second year, the data for the five schools is given either as an overall mean, or in terms of the range of values, whichever seems the more appropriate. The range of upward means was from 28.32 to 31.78 for 36 items. That for downward was from 24.39 to 30.31, while that for simultaneous intervals was from 23.65 up to 28.78. Standard deviations ranged from 3.5 up to 7.8 yielding reliabilities with three over .90, two below .80, and with the remainder in the .80's. The summary of this data is shown in Table VIII.

Table VIII

Statistical Data for the Other Schools Summarized

Other Schools	N	Mode	Items	Mean of medians	Mean of means	Range of St. Dev.	Range of Reliability
Spring '77 1st yr.	150	up	36	30.4	29.95	3.5-6.0	.61 - .93
		down	36	28.2	28.5	4.2-7.8	.84 - .92
		sim's	36	26.1	24.81	5.9-7.1	.79 - .92
2nd yr.	15	up	36	34.2	32.39	4.20	.84
		down	36	32.0	30.36	5.13	.83
		sim's	36	31.0	28.77	7.10	.92

VIII. Confusion Analysis -- Other Schools

The error and confusion data for the 165 students from the five other schools was summarized and compared with the Set of 54 Confusions from the SUI first year class and also the Set of 30 Basic Confusions from the same class with the results shown in the table following. It is interesting to note that at the first year level 93% of the upward, 95% of the downward and 83% of the simultaneous interval errors and thus 89% of all the errors made were accounted for through common confusion patterns. The Set of 30 accounted for 75% upward, 73% downward and 64% simultaneous and 69% of the total number of errors made. On the second year level the class of 15 students achieved quite similar results. Concerning the Set of 54 Confusions 65% of the upward, 73% of the downward and 79% of the simultaneous for a total of 74% of all the errors were found to be common. Because of the small number of students the common ground with the Set of 30 Basic Confusions was not computed. It seems correct to suggest that the Set of 54 Confusions is inclusive enough of the various interval confusion problems to constitute a a suitable basis for the study of interval recognition aurally. The Set of

30 Basic Confusions provides a beginning for such study but is not comprehensive enough to be fully effective.

Table IX

Confusions and Errors - Sets of 54 and 30, Other Schools

	12 two-way - all 3 modes	12 two-way - not 3 modes	6 one-way - not 3 modes	Set of 54 confusions	11 two-way - all 3 modes	3 two-way - not 3 modes	2 one-way - not 3 modes	Basic set of 30 confusions
1st yr.*--	(Total errors = 712 -- UP)				--(Total errors = 712 -- UP)			
- Con's-	22	17	4	43	20	5	2	27
- Errors-	446	190	22	665	400	106	15	533
% of Total--	63%	26%	4%	93%	57%	15%	2%	75%
--	(Total errors= 1024 - DN.)				-- (Total errors = 1024)			
- Con's-	23	18	3	44	16	6	2	24
- Errors-	631	281	66	978	608	118	16	742
% of Total--	62%	27%	6%	95%	59%	13%	1%	73%
--	(Total errors= 1435 -- SIM.)				-- (Total errors = 1435)			
- Con's-	22	20	4	46	22	4	2	28
- Errors-	827	213	146	1186	816	33	68	917
% of Total--	58%	15%	10%	83%	57%	2%	5%	64%

* The total number of first year students was 150 from five schools, the samples including 18, 18, 29, 40, and 44.

2nd yr. -- The small class of 15 second year students is dealt with in the following manner:

- Upward intervals -- 32 confusions and 60 errors
  19 random confusions and 19 errors
  13 sig. confusions and 41 errors that accounted for 65% of all the errors made. There was one significant confusion with 2 errors (m7/P5) that was not in the Set of 54.
- Downward intervals - 32 confusions and 68 errors
  18 random confusions and 18 errors
  14 sig. confusions with 50 errors that accounted for 73% of all the errors made.
- Simultaneous intervals - 42 confusions and 90 errors
  15 random confusions and 15 errors
  25 sig. confusions with 71 errors that accounted for 79% of all errors made. There were two sig.

confusions with four errors (P8/P4; M6/P4) that were not in the Set of 54.

IX. Confusions and Quintiles - All Samples.

One result anticipated in this project was a determination of just when specific interval confusions became problems. Since intervals do differ in difficulty, is it possible that certain types of errors will tend to associate with certain levels of competency? This project has already shown that the Set of 54 Confusions of the SUI first year class has been able to account for about 75% to 95% of all interval errors made and this suggests that the other 78 possible interval confusions either had no errors or did not have enough to be considered significant problems.

The errors made by all the students involved in this project were organized by the quintile level at which they occurred and then summed to assign relative importance to each confusion in each of the three performance modes. In Table X all significant values of the 54 intervals confusions are listed in the order of their apparent difficulty as determined in the above manner.

Table X

54 Interval Confusions - by Overall Difficulty and Mode of Performance

Overall difficulty	Upward intervals	Downward intervals	Simultaneous intervals
1. M7/tt - 375	1. M7/tt - 104-2*	1. M7/m7 - 104-3	1. P4/P5 - 136-1
2. m7/M7 - 268	2. m6/tt - 72 -2	2. M7/tt - 104-2	2. m7/M7 - 106-1
3. m7/m6 - 246	3. m7/m6 - 64 -3	3. m2/M2 - 93 -2	3. m3/M3 - 92 -2
4. m2/M2 - 245	4. m6/m7 - 64 -3	4. m7/M7 - 92 -1	4. M7/tt - 90 -3
5. M3/m3 - 234	5. M7/m7 - 63 -2	5. m7/m6 - 80 -2	5. m6/P4 - 87 -2
6. M7/m7 - 230	6. m2/M2 - 56 -4	6. M3/m3 - 72 -3	6. m6/M3 - 86 -1
7. m3/M3 - 223	7. M7/m6 - 49 -2	7. M7/m6 - 65 -2	7. m6/M3 - 76 -2
8. P4/P5 - 217	8. m3/M3 - 48 -2	8. m3/M3 - 62 -3	8. tt/m7 - 73 -2
9. m6/M6 - 202	9. m6/M6 - 46 -1	9. m6/M6 - 60 -2	9. M2/m2 - 73 -2
10. m6/m7 - 174	10. tt/M7 - 42 -2	10. m6/m7 - 56 -2	10. P5/P4 - 67 -3
11. P5/P4 - 146	11. tt/m6 - 41 -3	11. tt/m6 - 52 -3	11. m6/M6 - 64 -3
12. tt/M7 - 144	12. m7/M7 - 40 -3	12. M6/m6 - 49 -2	12. m2/M2 - 63 -3
13. m7/tt - 142	13. P8/P5 - 39 -2	13. P5/M6 - 43 -2	13. m7/tt - 58 -2
14. M7/m6 - 134	14. M6/m6 - 39 -2	14. m7/tt - 41 -3	14. m7/m6 - 55 -2
15. M6/m6 - 134	15. tt/m7 - 39 -3	15. M6/tt - 41 -2	15. M7/m7 - 51 -3

Table X (continued)

Overall difficulty	Upward intervals	Downward intervals	Simultaneous intervals
16. M2/m2 - 128	16. P5/P4 - 33 -2	16.m7/M6 - 40 -2	16. tt/M7 - 49 -3
17. tt/m7 - 119	17. M3/m3 - 33 -2	17.P4/P5 - 40 -4	17. M6/M3 - 44 -2
18. tt/m6 - 112	18. M6/m7 - 31 -3	18.M7/M6 - 36 -3	18. M6/m6 - 38 -3
19. m6/P4 - 107	19. M3/P5 - 26 -4	19.tt/P4 - 36 -3	19. m6/P5 - 38 -4
20. P8/P5 - 96	20. m6/M7 - 24 -2	20.P4/tt - 36 -3	20. M3/M6 - 37 -3
21. m6/tt - 89	21. P4/P5 - 24 -3	21.P4/M3 - 36 -3	21. M3/P4 - 37 -3
22. M3/P5 - 89	22. m6/P5 - 22 -4	22.M2/m2 - 32 -3	22. m3/M6 - 33 -3
23. m3/M3 - 84	23. M6/M7 - 18 -3	23.P5/M3 - 29 -3	23. M3/P5 - 30 -4
24. M3/P4 - 76	24. M2/m3 - 18 -5	24.tt/m7 - 25 -2	24. m6/m3 - 28 -3
25. m7/M6 - 72	25. M2/M3 - 17 -5	25.P5/P4 - 24 -3	25. tt/m3 - 23 -3
26. M6/m7 - 71	26. m7/tt - 16 -2	26.M3/P5 - 24 -4	26. P4/M3 - 21 -4
27. M6/tt - 68	27. P5/m6 - 15 -4	27.M3/P4 - 24 -5	27. P8/P5 - 19 -4
28. P4/M3 - 68	28. m6/P4 - 14 -4	28.tt/M7 - 23 -2	28. m7/M6 - 18 -2
29. P5/M3 - 67	29. P5/M3 - 14 -5	29.tt/P5 - 23 -5	29. P5/M3 - 17 -5
30. m6/P5 - 66	30. tt/m3 - 13 -5	30.m6/M7 - 21 -4	30. M6/P5 - 16 -4
31. P5/M6 - 62	31. M3/P4 - 13 -5	31.P4/m3 - 20 -3	31. P5/M6 - 16 -4
32. tt/m3 - 53	32. M2/m2 - 12 -3	32 M6/m7 - 19 -3	32. m3/P4 - 16 -4
33. m6/M7 - 51	33. P4/M3 - 11 -4	33.m3/m6 - 19 -3	33. tt/P5 - 15 -3
34. M7/M6 - 50	34. M7/M6 - 9 -5	34.M6/M7 - 17 -3	34. m3/P5 - 15 -3
35. tt/P4 - 47	35. P4/m3 - 9 -5	35.M2/M3 - 17 -5	35. P4/m3 - 13 -4
36. tt/P5 - 46	36. tt/P5 - 8 -5	36.M2/m3 - 15 -4	36. M2/m3 - 13 -4
37. M2/m3 - 46	37. m3/P4 - 8 -5	37.P8/P5 - 14 -5	37. M6/tt - 12 -4
38. M6/M3 - 44	38. m7/M6 - 6 -4	38.m3/P4 - 14 -5	38. P5/m6 - 12 -4
39. P4/m3 - 42	39. m3/tt - 6 -5	39.M6/P5 - 12 -3	39. P5/P8 - 10 -3
40. M2/M3 - 40		40.P5/P8 - 8 -4	40. tt/m6 - 10 -3
41. M3/M6 - 38		41.P5/P8 - 8 -4	41. M6/m3 - 9 -5
42. m3/P4 - 38		42.m3/tt - 8 -5	42. m3/m6 - 9 -5
43. M6/M7 - 35		43.m6/tt - 7 -3	43. M7/m6 - 7 -3
44. m3/M6 - 33		44.M6/m3 - 6 -4	44. m6/m7 - 7 -5
45. m6/m3 - 32			45. m6/tt - 7 -3
46. m3/m6 - 32			46. M2/M3 - 6 -5
47. M6/P5 - 31			47. m3/tt - 5 -5
48. P5/m6 - 29			
49. M6/m3 - 26			
50. P5/P8 - 22			
51. m3/tt - 19			
52. m3/P5 - 17			
53. P4/tt - 4			
54. M3/m6 - 3			

All confusions with 4 errors or less were considered to be either non-significant or random.

* The number following the hyphen indicates the quintile level within which the particular confusion became significant.

X. Concerning Interval Difficulty Order - All Samples

Most aural skills teachers have given thought to the relative difficulty of intervals but the research literature in this area is thin. The Killam, et al, report[1] knowledgeably suggests that difficulty does not increase directly with increasing interval size, since for example, the perfect octave as the largest simple interval is almost always the easiest to recognize.

The present project indicates that interval difficulty may vary considerably for most intervals, but that, by and large, the twelve basic intervals show hierarchical tendencies based on their associated error counts.

Table XI

Interval Orders of Difficulty - All Modes, All Samples *

Upward		Downward		Simultaneous		Total	
m6 - 40.4%	(errors) 35%	m7 - 46.9	41%	m6 - 54.9	46%	m6 - 45.0	42%
M7 - 39.5		M7 - 45.2		m7 - 42.3		M7 - 41.2	
m7 - 32.4		M6 - 40.1		M7 - 40.1		m7 - 40.5	
tt - 29.4		m6 - 39.8		M3 - 35.2	29%	tt - 30.6	24%
M3 - 18.0	16%	tt - 32.3		m3 - 32.2		M6 - 28.2	
M6 - 17.3		M3 - 22.1	19%	tt - 32.1		M3 - 25.1	
P5 - 16.8		m3 - 20.8		M6 - 27.3		m3 - 22.9	
m3 - 15.9		m2 - 18.9		P4 - 27.0		P5 - 19.6	
m2 - 14.7		P4 - 18.1		M2 - 26.6		P4 - 18.8	
P4 - 11.4	10%	P5 - 16.2		P5 - 25.9		m2 - 17.6	15%
P8 - 9.2		M2 - 14.1	10%	m2 - 20.3	17%	M2 - 16.2	
M2 - 8.0		P8 - 6.7		P8 - 13.5		P8 - 9.8	

Table XI shows that four intervals (m6,M7,m7 and tt) incurred an upward error burden which increased to 41% for five downward intervals (adding the M6) and grew further to 46% for three of the original four (less the tt) as simultaneous intervals. In the total column the tt mean was ten percentage points below the three highest intervals. On the low side, the P8, M2 and m2 gave a total mean error of 15%, but only the P8 was consistently low. In the melodic modes the m2 reached higher than expected levels and in the simultaneous mode the M2 was rather higher than the m2 in error. Note that the mean totals for the P4 and P5 are quite low with the P4 at the easy level in the upward mode, but more than twice as difficult in the simultaneous mode. Melodically the P5 showed a moderate error level but this was half again as high in the simultaneous mode. In the middle group the M6 was especially variable.

Another perspective becomes visible when the summed up, down, and simultaneous modes of the University of Iowa samples are compared with the same totals for the other schools and also for the Killam project, cited before.

In Table XII the stability of the m6,M7 and m7 is obvious with the tt somewhat more variable and less difficult. At the middle level the me proved to be consistent with the M3 and P5 more variable, while the P4 and M6 were especially variable. At the lowest level the P8 was consistent, but the seconds in the SUI sample were shifty.

Table XII.

Another Comparison of Interval Difficulty Orders - 3 Modes Summed

SUI-F,S	Other-F,S	Project-F,S	Killam, et al [1]
N - 448	N - 165	N - 613	N - 15
m6	m6	m6	m6
M7	M7	M7	m7
m7	m7	m7	M7
tt	M6	tt	tt
M3	tt	M6	m3
M6	M3	M3	M2
m3	m3	m3	M6
P5	P4	P5	P5
m2	P5	P4	P4
M2	m2	m2	m2
P4	M2	M2	M3
P8	P8	P8	P8

It is of special interest to note the interval order from the Killam et al report. The four most difficult intervals correspond nearly exactly and overall, therefore, eight. Three points are of interest in making this last comparison: (1) The Killam report involved 15 students, the current project, 613. (2) Each item in the Killam project was sounded either .1 or .2 seconds; in the current project each item sounded between 1 and 2 seconds. (3) In the Killam project each student responded in his own time; in the current project a new item was played each 15 seconds.

XI. Observations and Conclusions

The over-riding goal of this project was to provide information that could serve as guide lines for improving instruction for the aural identification of intervals. The following observations may, at the least, be of some interest, and can, at the most, perhaps be considered to hint at a few interval hearing characteristics of the general music population of students.

1. Intervals vary in difficulty in the performance modes, but some general tendencies are apparent.
   a. The m6, M7, m7, and tt are the most consistently difficult.
   b. The P8 is easiest, with the m2 and M2 variably easy usually.
   c. In the middle group the m3 and P5 are the more consistent, and the M3 and M6 the most variable, with the P4 less variable.
2. Confusion patterns are also evident.
   a. Perhaps strangely, the M7/tt pattern has the most errors - 375.
   b. The m2 had only one significant confusion (m2/M2), but it had 245 errors.
   c. The P8 had but one such confusion (P8/P5) and this had 96 errors.
   d. The m6 was involved in 8 significant patterns, the tt and M6 had 7 and the m3 had 6 confusion patterns.
3. The individual intervals are important in particular performance modes.
   a. In the upward mode -- the m2.
   b. In the simultaneous mode—the M2, P4 and P5
   c. The M3 is important in both the downward and simultaneous modes.
   d. In all performance modes -- the m3, tt, m6, m7 and M7. The M8 and P8 are also important in all performance modes, but less so.

A student's proficiency changes in the course of training. By this token it seems reasonable that the student's functional ability to recognize intervals changes accordingly. In a practical sense this would change a student's quintile placement in interval hearing. Hence, it is thought that some listing of quintile levels and likely confusion problems could serve as guide lines for providing remedial training. Each quintile is considered in turn, briefly.

- Quintile 1. Almost no problems; most errors are random or hint at problems that arise in later quintiles.
- Quintile 2. In all modes -- confusions involving the m6, m7, M7 and tt.
  -- Upward - hints suggest m3 and M3 problems arising.
  -- Simult's - Problems with P4's and P5's begin.
- Quintile 3. In all modes -- the above, plus --
  -- Upward - hints suggesting m2 and M2 problems occur.
  -- Downward - adjacent interval confusions from the P4, up.
  -- Simult's - Problems with m2 and M2 begin.
- Quintile 4. In all modes -- the above, plus --
  -- Upward - small adjacent interval confusions occur.
  - tt confusions with small intervals occur.
  -- Downward - hints of P8 problems occur.
  - confusions involving 3rds and 5ths occur.
  -- Simult's - P8 problems begin.
- Quintile 5. In all modes -- the above, together with P8 problems in all modes.

A final hope is that this project will inspire more work in this and related areas concerning pitch perception to be accomplished with the end goal of improving student achievement.

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REFERENCES

1. Killam, R., Lorton, P., and Schubert, E., "Interval Recognition: A Study of Student Accuracy of Identification of Harmonic and Melodic Intervals," *Journal of Music Theory*, Fall 1975.pages 212-234.
2. Madison, Thurber, "Interval Discrimination as a Measure of Musical Aptitude," Archives of Psychology, No.268 (June, 1942), pages 1-99.
3. Ortmann, Otto, "Some Tonal Determinants of Melodic Memory," *Journal of Educational Psychology*, XXIV (September, 1933), pages 454-456.
4. Lundin, Robert W., "The Development and Validation of a Set of Musical Aptitude Tests," *Psychological Monographs*, Vol. 63, Whole Number 305 (1949), pages 1-20.
5. Ottman, Robert, *A Statistical Investigation of the Influence of Selected Factors on Sight Singing*. Ph. D. Dissertation, North Texas State University, 1956.
6. Hutton, Doris, "A Comparative Study of Two Methods of Teaching Sight Singing in the Fourth Grade," *Journal of Research in Music Education*, I/2 (Fall, 1953), pages 119-126.
7. Barnes, James W., *An Experimental Study of Interval Drill as it Affects Sight Singing Skill*. Ph. D. Dissertation, Indiana University, 1960.
8. Bolden, Joyce I., *The Influence of Selected Factors on Growth in Sight Singing and Rhythmic Reading.* Ph. D. Dissertation, Michigan State University, 1967.
9. Ritchie, Tom V., *A Study of the Effects of Diatonic Harmony upon the Aural Perception of Selected Melodic Fragments*. Unpublished Doctor's Thesis, Indiana University, 1960.
10. Marquis, James H., *A Study of Interval Problems in Sight Singing Performance with Consideration of the Effects of Context.* Unpublished Ph. D. Dissertation, University of Iowa, 1963.
11. Cooper, John D., *Development of a Sight Singing Achievement Test for Use with College Students*. Ph. D. Dissertation, University of Colorado, 1965.

COMPUTER-ASSISTED INSTRUCTION APPLICATIONS TO STANDARDIZED MUSIC ACHIEVEMENT TESTING

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Introduction:

The combination of two major areas in evaluation and instruction is currently the subject of research at the University of Illinois: these areas are 1) standardized testing, and 2) computer-assisted instruction. The Music Achievement Test series was developed from 1967 to 1970, resulting in a four level series of tests with national norms (Colwell, 1967, 1970). As the fourth level of MAT was being completed, research was initiated in the use of the PLATO computer for music instruction.

The recent (1977) development of software and hardware capabilities has made the present research project possible: that is, the combination of the MAT series and the PLATO music programs as a new delivery system. This exciting combination has potential, not only for music achievement testing, but for all types of standardized testing. The research has raised some interesting questions which have significant implications for the entire field of computer-assisted instruction.

Standardized Music Testing:

Standardized testing is an idea which has grown with force and power equal to any of the educational movements of the Twentieth Century. In the development and use of standardized aptitude and achievement tests, music has not been slighted. Seashore reported his first efforts at measuring musical aptitude as early as 1912; these efforts culminated in the publishing of the first standardized music test (Seashore, 1919). Seashore's test measured only aural skills, for he was convinced that aural ability was the result of aptitude, while other musical skills were more largely the result of training. The Seashore test was viewed as a potential godsend by the music and academic communities because the training of a musician is expensive, long, and arduous.

Judgment of musical performance remains today the most widely used criterion for admittance to formal musical instruction, and even, in many cases, for obtaining a teaching or performing position in music. However, other factors are increasingly seen as part of the common denominator of the musician, whether teacher, musicologist, composer, or critic. Aural skills, including those Seashore proposed, are now considered basic, both for instruction and as evidence of achievement. We now view many of these aural skills amenable to training, and not necessarily dependent upon aptitude as Seashore believed. Aural skills are often difficult to measure, but computer-assisted testing has made the development of standardized tests in music more feasible than at any previous time.

Audio Capabilities in CAI:

Since 1967, sound capabilities for the programing of CAI music materials have been improved. The technology for random-access recording and tape systems has existed for years, but only recently has it been developed to a state considered acceptable to the musician.

The PLATO Music Project at the University of Illinois began in 1970 with the investigation of the audio capabilities of the PLATO III computer-assisted instructional system. Two CAI projects in music were begun during the latter part of the 1969-1970 academic year: Placek (1972) designed lessons to implement a random-access audio device in an elementary music fundamentals program; at the same time, an interface was developed for the judgment of pitch and rhythm performance (Peters, 1974). The current research into computer-assisted testing is a logical projection of this early audio research.

The development of the digital to analog (D to A) interface for computers has been enhanced by the microprocessor. Acceptable one and four-voice sound generators sufficient for programing "perception" drills in music are being used successfully on several campuses. Continued developmental work will yield, within the present calendar year, a multi-voice tone generator with machine-controlled timbre and enveloping capabilities.

Similar advancements in technology have revolutionized the possibilities for the development of the A to D interface for programing music performance juding. Early studies by Allvin (1967) and Peters (1974) predate the many currently available integrated circuits and processing units. Although this capability is not currently needed for the Music Achievement Tests, the added capability of evaluating performance in a systematic manner is very attractive when considering the computer consistency in pitch and rhythm judgments.

Computer-Assisted Test Administration in Music:

When first conceived, the idea of standardized tests administered with the aid of the computer yielded the obvious advantages of rapid scoring, immediate accessibility to norms, and the ability to call instantly needed data in interpreting scores rather than wading through the cumbersome manuals mandated to meet the cautions of the AERA and APA in the Standards for Educational and Psychological Tests. The additional concerns created by social consequences of music testing seemed resolvable through this application of the computer.

Easy access to data collection and evaluation makes the application of standardized testing and CAI a natural result. Although use of a standardized test is still appropriate when one has to make only one or a limited number of choices, the basic format of testing has become less acceptable. Paper and pencil tests are cumbersome. Hand scoring of tests is not only time consuming but potentially inaccurate. Of greater significance is the disruptive nature of administering a standardized test in areas where test-taking is infrequent. The freedom of the classroom occasioned by individualized instruction, CAI, nongraded schools, and independent learning is not compatible with testing when everyone must stop what he is doing to take the test. Music tests require a phonograph or tape recorder, almost total silence to minimize interference from others, a need for everyone to progress at the same pace; all activities foreign to contemporary learning theory. In other words, a student is tested in a context unlike that in which he learned, raising a major concern for content validity.

Many unexplored advantages of the computer administration of music tests soon become apparent. With both aural and visual capabilities developed in CAI, the student has better reinforcement than is possible with the usual configuration of the teacher giving some directions, accompanied by limited directions on the machine-scored answer sheet, and additional directions and examples on the tape or recording. Coordination of visual and aural directions is possible so that the role of the teacher can be eliminated.

A second advantage is that the student can ask that the aural directions be repeated, thus insuring that he understands the task, the procedure, the method of responding, and any score procedures that might affect the way he approaches the task. A way has been found to (1) avoid the critical problem of "mind wandering" during the giving of directions and (2) attenuate the negative effects of speeded tests, a characteristic of all music tests using aural stimuli. These minor modifications, possible with PLATO, in all likelihood, improve the validity of any test.

PLATO provides the choice of computer-generated sound or generation of stimuli from high-fidelity tape. Music aptitude tests have long been criticized because computer-generated sound was amusical, yet computer-generated sound remains the most viable method to test pitch differentiations of less than a half step, an important distinction in music. Further, computer-generated sound can be controlled for overtones, timbre, dynamics, attack and steady state of the tone and other variables which may interfere with a subject's ability to distinguish pitch. (Recall that in music pitch is the consideration, not frequency.) Tape-generated stimuli, while possibly musical, possessed not only a lack of control but were inconsistent in quality, and were influenced by prior learning and familiarity and thus subject to cultural biases. Computer-assisted testing will make possible the investigation of the effect of the type of stimuli and thus obtain some valid measures of pitch discrimination.

A troublesome question for both testing and learning is the positive and negative effects of immediate feedback. If the student views CAI as a test, is there a relationship between programing and testing via the computer? With a standardized test, should the student receive immediate feedback as to the correctness of his answer? What is the role of a neutral response that merely encourages the student to proceed to the

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next question? If the student can determine his score immediately after completing the test and before the teacher knows the score, how does this affect the student's class performance and relationship to the teacher? If the teacher is not able to comment on the meaning of a computer assigned grade and has a reason to sit down with the student and go over his work, how does this affect the testing situation?

The answer to these questions are important if we are to use the computer for testing as well as teaching. The answers are also critical to interpreting the results of standardized tests given via computer. Validity, which is the most crucial element in education as well as in testing, has been found to be enhanced by the use of the computer. The computer enables us to move closer to measuring, because we are able to remove much of the error of the testing situation as well as some of the errors in the test instrument. Interestingly, we do not know, in administering standardized tests with PLATO, whether we have invalidated the norms. In achieving greater standardization and a more valid instrument, have we raised or lowered test scores? This question is as yet unanswered.

MAT Computer Program Development:

The operation of the MAT computer program utilized the PLATO terminal equipped with the "Gooch Music Box", a digital-to-analog device for production of music. The program written for MAT stored the raw score for each student by test-section. The student raw score was then compared to the standardized percentile scores before being stored in permanent records. Raw scores, as well as computer percentile scores, were retained during the study.

Added program capability allowed the teacher/researcher to review student scores by group or class level. This graphic display aided in comparing control-group with the experimental group; or for the teacher in comparing the class with national, school district or regional norms as they develop. By increasing the data-base, scores for students could be retained for a longitudinal study by a single teacher or an entire school district.

Data was collected as MAT was administered in all of the following modes of presentation:

1. by PLATO with the "Gooch Music Box".

2. by PLATO with random-access tape playback, controlled by computer.
3. by the classroom teacher as per normal manual instructions. (This method required the use of a long-playing phonograph record and machine-readable score sheets.)

Program development involved the recording of new test instructions for students taking the random-access audio version of the test. All actual music examples and test items were transferred directly from the phonograph recording to the random-access audio recording for testing purposes.

Programming of the "music box" version of MAT 1 required the encoding of all music materials into computer code. In this manner, all music examples and test items were programed directly into the computer test (lesson). Care was taken to reproduce the computer-generated music items at the same pitch and tempo as those recorded for the original test.

Replacing the standardized optical-scan test form were written instructions appearing on the PLATO terminal screen. In the random-access audio version of MAT 1, student instructions were given in recorded verbal form, as they also appeared on the computer screen. This is similar to the procedures of the traditional method of administering the test, i.e., recorded instructions and test form examples. In the music-box version of the test, no verbal instructions were given to the student. In this method, the student was required to read the instructions, try questions, and proceed, with no other instructions. Although it was possible to incorporate verbal instructions from the random-access audio with the music box method, it was not part of the experimental design.

In reviewing the data, evaluation was made of the three different means of administering the test to students randomly selected from grade schools in Champaign, Illinois.

Results from pilot testing of the MAT programs have yielded positive results, in that students had no difficulty with the computer-administered forms of the test. Data is still being collected to determine the difference and significance of the electronically produced "Gooch Music Box" sound as compared to the recorded instrumental music examples. Although this difference may be of little concern in the non-music test areas, the question of transfer and pitch perception must be resolved in this case.

All data-collection programing routines functioned as anticipated. Student records for each participant stored information of part-scores, raw score, percentile by region, grade, and national norms. Added information was reviewed on the time students needed to complete the test on the PLATO system.

Conclusions:

Initial reaction to the PLATO administration of D-to-A testing in music has been positive. The immediate feedback available by computer, plus the individual pacing of the student are good causes for this early success. The mode of test presentation remains a major question for extensive further study. Whether to allow the student 1) repeated hearings of items, 2) reinforcement by item or section, and 3) an open time-frame, are all debatable points when comparing results to the early norming of standardized tests.

If computer administered testing is standardized in the future, the chore of item analysis and test validation can be an easy matter. It is possible to have a continuous updating of norms.

The evaluation community is presently divided over normative versus criterion referenced tests. The primary difference between the two types of instruments is in how they are used and in some areas, how they are constructed. Data on call are acceptable where printed data are not. We now have the potential that, by altering the program, the same test or a test with only a few items changed can serve as either a criterion-referenced test or a norm-referenced test.

In schools utilizing CAI, considerable benefit would accrue from the use of the computer for periodic evaluation. Teachers and researchers are primarily interested in gains by question, task, or some small component of a test than in the total score. The use of graphics on raw scores or profiles of students allows for diagnostic work never before possible. The advantages of using CAI systems for systematic evaluation appear to be as great as the uses of CAI for instruction.

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References

Allvin, Raynold. The Development of a Computer-Assisted Music Instruction System to Teach Sight Singing and Ear Training. DMA Dissertation, Stanford University, 1967.

Colwell, Richard J. Music Achievement Tests, I, II, III, IV. Chicago: Follett Educational Corporation, 1967 and 1970.

Deihl, Ned. Development and Evaluation of Computer-Assisted Instruction in Instrumental Music, Report No. R-24. University Park: CAI Laboratory, Pennsylvania State University, 1969.

Dicks, Ernest. A Handbook of Examinations in Music. London: Novello and Company Ltd., 1898.

Hofstetter, Fred T. Foundation, Organization, and Purpose of the National Consortium for Computer-Based Music Instruction. Newark: University of Delaware, 1975.

Peters, G. David. The Development of Computer-Assisted Instructional Materials for Use in the Teaching of Instrumental Music Via PLATO IV. Final Report: Undergraduate Instructional Award. University of Illinois, 1974.

_______________. Feasibility of Computer-Assisted Instruction for Instrumental Music Education. Ed.D. Dissertation, University of Illinois, 1974.

Placek, Robert W. Design and Trial of Computer-Assisted Lessons in Rhythm. Journal of Research in Music Education, 1974, XXII, 13-23.

Seashore, Carl E. Seashore Measures of Music Talent. New York: Columbia Phonograph Company, 1919.

Computer-Based Recognition of Perceptual Patterns in Harmonic Dictation Exercises

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- Abstract -

During the 1975-76 academic year student response data was saved for a group of seventeen freshman music majors as they worked through fifteen units of harmonic dictation exercises delivered on the University of Delaware's GUIDO system. Analysis of the student data base led to the identification of seven confusion tendencies which affect the perception of harmonies: bass line confusions, confusions by inversion, confusions by chord function, confusions by chord quality, unperceived sevenths, unperceived roots, and favorite response confusions. The level of student achievement on individual harmonies was found to be highly correlated with the percentage of times these harmonies are asked in the curriculum.

- Introduction -

During the 1974-75 academic year a computer-based dictation system called GUIDO was developed at the University of Delaware. GUIDO is an acronym for Graded Units for Interactive Dictation Operation, named after Guido d'Arezzo, the eleventh century musician and music educator who invented the staff and established the principles of solmization. The learning stations in this system consist of digital synthesizers through which the computer plays dictation exercises, and high-speed graphics terminals which display musical notation, ask questions, and record student responses.

It has previously been reported how an experiment was run to determine the impact of this system on student achievement in harmonic dictation (Hofstetter, 1975). The experiment was conducted with a freshman ear-training class during the 1974-75 academic year. During the first semester, all 33 students received the same course of instruction in ear-training, with all drill-and-practice done in the tape laboratory. At the beginning of the second semester, the class was randomly split into two groups; 17 students were assigned to an experimental GUIDO group which practiced ear-training at the computer terminals, and 16 students were assigned to a control TAPE group which practiced in the tape laboratory. At the end of the first semester (before the implementation of GUIDO), the mean harmonic dictation scores of the GUIDO and TAPE groups were 77 percent and 76 percent, respectively. At the end of the experiment the mean scores were 86 percent for the GUIDO group and 75 percent for the TAPE group. The results of a t-test applied to the GUIDO and TAPE scores at the end of the experiment indicate that the difference between the two groups is significant at the .05 level.

The second phase of this project has been to use the record-keeping features of the GUIDO system to identify perceptual patterns in harmonic dictation exercises. As the students work through the dictation units, GUIDO collects information on how the students respond to each individual item in the dication exercises. During the 1975-76 academic year, records were saved for a class of seventeen freshman majors at the University of Delaware. The dictation exercises were taken from the Benward (1969) *Workbook in Ear-Training*. The resulting student records constitute a complete data base of student responses given during the course of Benward's harmonic dictation exercises. It is the purpose of the present study to analyze the data base and to report the patterns of student learning which can be discerned therein.

- Procedures -

The experiment was conducted in the context of the activities normally associated with freshman ear-training courses. The students met in class for two hours each week with the instructor, and they practiced dictation exercises on their own time for an additional two hours each week. The seventeen students participating in this experiment did the additional practice at the computer terminals. The GUIDO system normally allows the students to select the units of dictation exercises which they want to practice. In this study the choice of dictation units was controlled so that all students received the same sequence of harmonic dictation exercises. The sequence is given in Table 1, which shows the unit numbers and content of the harmonic dictation units. In order that the student response data could be interpreted in a single key with respect to one tonic, this experiment was limited to non-modulating dictation exercises.

Table 1

Harmonic Dictation Units Included in the Experiment

Sequence Number	Benward Harmonic Unit Number	Content
1	3A	I and V
2	4B	I, V, and VII^6
3	4E	I, V, and VII^6
4	5B	I, IV, V, and VII^6
5	5D	I, IV, V, and VII^6
6	6A	I, IV, V, and VII^6
7	6B	I, IV, V, and VII^6
8	6D	I, IV, V, and VII^6
9	7C	I, II, IV, V, and VII^6
10	8B	I, II, IV, V, and VII^6
11	8D	I, II, IV, V, and VII^6
12	9D	I, II, IV, V, V^7, and VII^6
13	10A	I, II, IV, V, V^7, and VII^6
14	11A	I, II, IV, V, V^7, VI, and VII^6
15	12D	I, II, III, IV, V, V^7, VI, and VII^6

The GUIDO system also normally allows the students to select the order in which they answer harmonic dictation questions. In this study the order was controlled so that all students were required to answer Roman numerals first, then soprano and bass lines. The GUIDO system saved all student responses to each harmony played in the dictation exercises. If the students got a harmony wrong, they were allowed to continue working until they got it right. In this study only the first response to each harmony was considered for analysis.

- Results -

In order to determine the overall pattern of student responses to the harmonic dictation exercises, cross tabulations were made for each harmonic dictation unit and for the complete set of all 15 units. By studying the cross tabulations for each individual unit a summary of student achievement was obtained for each harmony in the dictation exercises. Given in Table 2, this summary shows the units in which each harmony was asked, the units in which students showed mastery in the identification of individual harmonies, and the units in which students consistently gave the same wrong answer to a given harmony. Harmonies were considered to be mastered if the students answered correctly at least 70% of the time on the first try. 70% was the grand mean for all students on all exercises in the curriculum. Consistent wrong answers were defined to be those which were given at least 20% of the time. At the bottom of the table are given the mean scores for each unit. The range is from a low of 59 in unit 2 to a high of 82 in units 6 and 14.

Several response patterns can be seen in Table 2. First, there are those harmonies which are quickly mastered at the beginning of the curriculum and are not subsequently confused with other harmonies. These are I, i, V, and vii°_{6}. Second, there are harmonies which after their initial mastery are subsequently confused with other harmonies. These are I^{6} which is confused with I in unit 13; i^{6} which is confused with i in unit 7; IV which is confused with ii^{6} in unit 9; IV^{6} which is confused with iv^{6} in unit 12 and with vi in unit 15; iv which is confused with IV in unit 8 and ii°_{6} in unit 9; and V^{6} which is confused with vii^{6} in units 7, 8, 10, 11, and 12 and with V^{7} in unit 13. Third, there are those harmonies which are mastered after some initial difficulty and are not subsequently confused with other harmonies. These are I^{6}_{4} and iv^{6}. Fourth, there are those harmonies which are never mastered. These are i^{6}_{4} which is consistently confused with V; ii which is confused with vii°_{6} and IV; ii^{6} which is confused with IV; and ii°_{6} which is confused with IV and iv; iii^{6} which is confused with V; V^{7} which is confused with V; V^{6}_{5} which is confused with V^{6}; V^{4}_{3} which is confused with vii°_{6}; and V^{4}_{2} which is confused with ii°_{6} and ii. Finally there are the harmonies iii and vi which are not presented until the end of the curriculum but which are nevertheless immediately mastered.

Table 2

Summary of Student Achievement in Harmonic Dictation Exercises.

Roman Numeral	Harmonic Dictation Units														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
I	V	-	*	*	*	*	-	*	*	*	*	*	*	*	*
I^6	-	-	I	i^6	I	*	-	*	*	*	*	*	I	*	*
I^6_4	-	-	-	-	-	-	-	-	-	V	V	-	*	-	-
i	-	I	I	*	*	*	*	*	*	*	*	*	*	-	-
i^6	-	-	I^6	i	i	*	i	*	*	*	-	*	*	-	-
i^6_4	-	-	-	-	-	-	-	V	V	-	-	V	V	-	-
ii	-	-	-	vii^{o}_{6}	-	-	-	vii^{o}_{6}	-	vii^{o}_{6}	IV	IV	vii^{o}_{6}	vii^{o}_{6}	IV
ii^6	-	-	-	-	-	-	-	-	IV	IV	IV	IV	IV	IV	IV
ii^{o}_{6}	-	-	-	-	-	-	-	IV	iv	-	iv	IV	IV	-	-
iii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*
iii^6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V
IV	-	-	-	*	*	*	-	*	ii^6	*	*	*	*	*	*
IV^6	-	-	-	-	-	V	-	iv^6	IV	*	*	iv^6	*	-	vi
iv	-	-	-	IV	V	*	*	IV	ii^{o}_{6}	*	-	-	*	-	-
iv^6	-	-	-	iv	-	-	iv	*	-	-	*	*	*	-	-
V	I	*	*	*	*	*	*	*	*	*	*	*	*	*	*
V^6	-	-	vii^{o}_{6}	vii^{o}_{6}	V	*	vii^{o}_{6}	vii^{o}_{6}	-	vii^{o}_{6}	vii^{o}_{6}	vii^{o}_{6}	V^7	-	-
V^7	-	-	-	-	-	-	-	-	-	-	-	V	V	-	V
V^6_5	-	-	-	-	-	-	-	-	-	-	-	-	V^6	V^6	-
V^4_3	-	-	-	-	-	-	-	-	-	-	-	-	-	vii^{o}_{6}	-
V^4_2	-	-	-	-	-	-	-	-	-	-	-	-	ii^{o}_{6}	ii	-
vi	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*
vii^{o}_{6}	-	V	*	*	*	*	*	*	*	*	*	*	*	-	-
$\overline{X}$	.74	.59	.64	.71	.70	.82	.75	.73	.68	.78	.76	.61	.61	.82	.71
SD	.44	.49	.48	.45	.46	.38	.43	.44	.47	.41	.44	.49	.49	.39	.45

Key: " - " means a harmony was not asked in a given unit.
" * " means a harmony was correctly answered more than 70% of the time.
Roman numerals are given when they are confused with the correct answer more than 20% of the time.

Table 3 contains a cross tabulation of correct answers and student responses for all of the harmonic dictation units. Examination of this table leads to the identification of seven principles of chord confusion which account for all of the student errors which occur at least 10% of the time. Errors occurring less than 10% of the time are not discussed in this paper. The percentages of times the students gave correct answers are found on the diagonal line drawn on the table. The other numbers in the table indicate the percentages of the times wrong answers were given. These are categorized by seven symbols drawn around the numbers corresponding to the seven principles of chord confusion which are described as follows:

Principle One: Bass Line Confusions. The most common confusion tendency involves chords which have the same bass notes. The percentages of confusions according to this principle have been circled in Table 3. I^6_4 is often confused with iii^6, while i^6_4 is confused with V. It has been generally believed that tonic six-four chords are often confused with dominant chords. The data in Table 3 indicates that this is much more true of the minor i^6_4 than it is of the major I^6_4, which is actually confused more often with iii^6 than it is with V.

ii is confused with vii^6_5, a chord with the same bass note but with a different harmonic function. ii^6 is confused with IV, and ii^6_5 is confused with iv. These pairs of chords share the same bass notes, and they have the same subdominant harmonic function. iii is confused with I^6 and iii^6 with I^6_4. These pairs of chords share two common notes, although they have dissimilar harmonic functions. iii^6 is also confused with V, supporting the theory that it can function as a dominant substitute.

V^4_3 is confused with ii, a chord with the same bass note but with a much different harmonic function. V^4_2 is similarly confused with ii^6 and ii^6_5, and also with IV, chords with the same bass notes and with subdominant functions.

Principle Two: Confusions by Inversion. Only three chord confusions occurred under this principle whereby the correct Roman numeral is answered with the wrong inversion. i^6 was confused with i, iv^6 with iv, and V^6 with V. A square has been drawn around the percentages of these confusions in Table 3. It has generally been believed that confusions of this type can occur on any degree of the scale, and in any mode. The data in Table 3 show that this principle affects only i^6, iv^6, and V^6.

Principle Three: Confusions by Chord Function. Four of the confusions discussed under principle one, bass line confusions, can also be classified under principle three as confusions by chord function, namely, i^6_4 and V (dominant), ii^6 and IV (subdominant), ii^6_5 and iv (subdominant), and iii^6 and V (dominant). Confusions under principle three have been marked with a " △ " in Table 3. Noticeably absent from the list of confusions under this principle is the chord substitute vi for I.

TABLE 3

Cross Tabulation of Correct Answers and Student Responses for
All Harmonic Dictation Units; Numbers Given in the Matrix
are Percentages of the times the Student Responses were Given

STUDENT RESPONSES \ CORRECT ANSWERS	I	I^6	I^6_4	i	i^6	i^6_4	ii	ii^6	ii^6_5	iii	iii^6	IV	IV^6	iv	iv^6	V	V^6	V^7	V^6_5	V^4_3	V^4_2	vi	vii°_{6}
I	85	15	5	▽17	4	—	3	1	1	1	2	4	—	—	4	8	2	—	—	—	—	—	6
I^6	1	65	—	—	6	2	1	1	—	○11	1	5	2	1	—	1	1	—	5	—	—	2	1
I^6_4	—	—	80	—	—	1	—	—	—	—	○11	—	2	—	—	—	—	—	—	—	—	—	—
i	1	—	—	71	□13	6	—	1	3	1	—	—	4	6	5	4	4	8	—	—	—	1	5
i^6	—	2	—	1	81	6	—	—	5	—	—	1	—	6	4	—	2	—	—	—	5	—	1
i^6_4	—	—	—	—	1	67	—	—	1	—	—	—	—	—	2	—	—	—	—	—	5	—	—
ii	—	2	—	—	1	—	23	5	—	1	2	2	4	—	—	—	—	—	—	○30	—	1	3
ii^6	—	1	—	—	—	—	1	33	3	—	—	6	4	1	—	—	—	3	5	—	○21	1	—
ii^6_5	—	—	—	—	1	—	—	—	60	—	—	—	—	2	—	—	—	—	—	—	○11	—	—
iii	—	1	—	—	2	—	—	—	—	70	6	2	—	—	—	—	—	—	—	—	—	1	—
iii^6	—	—	○13	—	—	—	—	2	—	—	50	—	—	—	—	—	—	—	5	—	—	1	—
IV	2	5	—	1	1	—	△16	△42	6	6	6	65	1	6	1	1	2	—	—	5	○11	2	2
IV^6	—	1	—	—	—	—	—	2	—	—	—	1	53	1	—	—	1	—	—	—	—	6	—
iv	—	—	—	2	6	6	1	—	△43	—	—	1	6	64	□16	1	1	1	—	—	5	—	2
iv^6	—	—	—	—	1	2	—	—	—	—	—	—	▽16	1	61	—	1	—	—	—	—	—	—
V	6	1	6	1	2	△32	6	6	6	5	△22	1	5	6	12	78	□11	▷67	5	—	—	6	△13
V^6	—	6	1	—	—	—	1	1	2	—	—	—	6	1	1	1	55	—	▷53	—	—	1	3
V^7	—	—	2	—	—	1	—	—	—	1	6	—	—	—	—	1	2	23	—	—	—	1	—
V^6_5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	27	5	—	—	—
V^4_3	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	5	5	5	—	—
V^4_2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	27	—	—
vi	—	—	—	—	—	—	1	1	—	1	6	—	6	—	—	—	—	—	—	—	—	73	—
vii°_{6}	—	1	—	5	1	2	○23	1	—	1	—	2	3	3	—	1	△10	—	—	◁30	△16	—	59
Others[a]	2	1	2	2	—	—	—	—	4	3	6	2	—	—	—	2	1	—	1	5	—	5	8
N[b]	1440	600	74	2330	304	150	100	225	122	152	90	404	114	304	114	2050	402	130	18	40	18	257	836
N%[c]	16.2	5.2	0.6	19.3	2.5	1.2	1.4	1.8	1.0	1.2	0.7	1.9	0.9	1.5	0.9	22.4	3.5	1.1	0.3	0.3	0.3	2.3	7.2

[a] "Others" are responses that were not in the list of possible answers.

[b] "N" is the number of times the chord was asked.

[c] "N%" is the percentage of times the chord was asked.

○ = Bass Line Confusions
□ = Confusions by Inversion
△ = Confusions by chord function
▽ = Confusions of chord quality
▷ = Unperceived seventh
◁ = Unperceived root

Principle Four: Confusions of Chord Quality. Only two examples of the confusion of chord quality were found, namely, the confusion of IV^6 and iv^6, and of i and I. These have been marked with a " ▽ " in Table 3.

Principle Five: Unperceived Seventh. In the perception of the V^7 chord and its first inversion a common problem was that students did not recognize the presence of the seventh. They confused V^7 with V, and V^6_5 with V^6. These confusions have been identified by a " ▷ " in Table 3.

Principle Six: Unperceived Root. 50% of the time students confused V^4_3 with $\mathrm{vii}^{\circ 6}$, the spelling of which is identical to a V^4_3 minus the root. This confusion has been marked with a " ◁ " in Table 3.

Principle Seven: Favorite Response. The six principles given above account for all of the percentages in Table 3 greater than 10% except for one, namely, the confusion of iv^6 and V. These two harmonies have no notes in common, and their functions are most dissimilar. The only explanation for this confusion is that V was the most frequently used wrong response in the data base, and if students did not have any idea what to name a harmony, their most frequent guess was V.

The last two rows of Table 3 give the number of times each harmony was asked throughout the curriculum, and the percentage of times each harmony was asked, respectively. A wide variation exists in the percentages which range from .3% for inversions of V^7 to 19% for the tonic triad. This variation led to the question of whether the number of times a harmony is asked is related to the percentage of times that harmony is answered correctly. A product moment correlation was done for each unit and for the whole population based on the percentage of times each chord was asked and the percentage of times each chord was correctly answered. Table 4 contains the resulting correlation coefficients. The high correlations found in most units indicate that students do better on harmonies which are asked a lot. It stands to reason that harmonies which are asked more and therfore practiced more will be learned better than those which are asked less frequently. Therefore, one way of increasing student achievement of the difficult harmonies may be to increase the percentage of times they are asked.

Table 4

Pearson Correlation Coefficients for the Percentage of Correct Answers for Each Harmony with the Percentage of Times Each Harmony Was Asked in Each Unit and in the Whole Population.

Unit	Correlation Coefficient	Content
1	.99	I and V
2	.95	I, V, and VII^6
3	.57	I, V, and VII^6
4	.60	I, IV, V, and VII^6
5	.66	I, IV, V, and VII^6
6	.35	I, IV, V, and VII^6
7	.44	I, IV, V, and VII^6
8	.76	I, IV, V, and VII^6
9	.36	I, II, IV, V, and VII^6
10	.51	I, II, IV, V, and VII^6
11	.66	I, II, IV, V, and VII^6
12	.79	I, II, IV, V, V^7, and VII^6
13	.52	I, II, IV, V, V^7, and VII^6
14	.66	I, II, IV, V, V^7, VI, and VII^6
15	.86	I, II, III, IV, V, V^7, VI, and VII^6
All 15 Units	.65	All Harmonies

- Discussion -

Considering the data included in this study five observations can be made about the design of Benward's harmonic dictation exercises. First, the average score for all seventeen students in all fifteen units is 70%. The means of the individual units range from 59% to 82%. The level of difficulty is fairly consistent throughout the curriculum.

Second, especially noteworthy is the immediate mastery of the harmonies iii and vi, which are not introduced until the end of the curriculum. Benward has done an exceptional job in designing the curriculum in such a way that these harmonies are learned so quickly.

Third, a weakness in the curriculum concerns those harmonies which are never mastered. These are i^6_4, ii, ii^6, ii^6_5, V^7, and the inversions of V^7. The product moment correlations indicate that one way of improving student performance of these chords may be to increase the frequency of their occurence in the curriculum.

Fourth, there is no one confusion pattern which affects all of the harmonies; on the contrary, the confusion patterns are selective. Bass line confusions affect the perception of the tonic six-four chords, the first inversions of the supertonic chords, both root positions and first inversions of the mediant chords, and the second and third inversions of the dominant seventh chord. Confusions by inversion affect the perception of only three chords, namely, i^6, iv^6, and V^6. Confusions by chord function affect the perception of tonic six-fours, supertonic, mediant, and dominant chords; they do not occur in subdominant, submediant, and leading-tone chords. Confusions of chord quality affect the perception of root position tonic triads and first inversion subdominant triads. Inversions of the dominant seventh chords are affected by unperceived roots and unperceived sevenths. The instructor's manual of the Benward text includes sections in which teaching techniques are discussed. It may be helpful to include in these sections information regarding the confusion patterns detected in this study so that instructors can watch for them and warn their students about them. Additional units could be specifically designed to give more practice in the confusion areas.

The continuation of this study will seek to determine not only the perceptual patterns discernible in existing harmonic dictation series, but also the best way of organizing dictation exercises. This will be pursued through the gradual cycle of design, evaluation, and redesign which has begun in the University of Delaware's GUIDO project. The perception of intervals, melodies, chord qualities, and rhythms are also under investigation in an attempt to realize what Allvin (1971) identified as a very important goal of computer-based education, namely, "to define the optimal sequential ordering of material within concept modules."

- References -

Allvin, Raynold L. "Computer-assisted music instruction: A look at the potential." Journal of Research in Music Education, 1971, 19, 136.

Benward, Bruce. Workbook in Ear Training, 2nd ed. Dubuque: Wm. C. Brown Company Publisher, 1969.

Hofstetter, Fred T. "GUIDO: An interactive computer-based system for improvement of instruction and research in ear-training." Journal of Computer-Based Instruction, 1975, 1, 100-106.

NATAL-74 : FIRST RESULTS

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NATAL-74 is a high-level programming language designed to meet the requirements of the course author in the preparation of Computer-Aided Learning (CAL) materials. The basis of the NATAL-74 design is found in the functional specification(1) published by the National Research Council's Associate Committee on Instructional Technology. This document was prepared by a Working Group whose members came from centres across Canada where they were actively engaged in CAL projects. In producing the functional specification, the working group members drew on their personal experience in a wide range of application areas with a variety of programming languages. In addition, the working group relied heavily on the 1969 EDUCOM report of Zinn(2), using his "aspects" for comparing programming languages as the basis for the definition of language requirements. Thus the functional specification was derived from input from a broad base of experienced users.

The detailed specification(3) for NATAL-74 was prepared by IBM Canada Ltd. under contract from NRC. Throughout this contract, the members of the Associate Committee on CAL Programming Languages provided comments and suggestions to the contractor. Late in 1974, the detailed specification was delivered and work started on the initial implementation of NATAL-74 on the DECsystem-10 computer which is used as the central computer facility in the National Research Council's CAL research project.

Design Goals

The fundamental objective of the NATAL-74 project is the development of a course-authoring language which meets user requirements and which permits the dissemination across system boundaries of computer-based course materials, without the cost of reprogramming those materials. Achievement of this objective is dependent on satisfying four major functional requirements

The first of these requirements is that the language must be based on a clearly defined standard which is capable of being implemented on the variety of computers which are used for CAL. This further implies the requirement that the language be defined in conformity with existing EDP standards issued by national and international standards bodies. To do otherwise would result in unnecessary and costly system programming changes in going from one manufacturers equipment to another.

A second main requirement is for the language to support the interactive applications common to CAL and which often involve the use of an extensive range of terminal equipment incorporating a variety of display-response capabilities. It should not be necessary for the user to change his program to permit it to run on a terminal which is different but functionally equivalent to the one on which it was developed. Any action required to adapt the user program in such a case should be carried out automatically by the CAL system.

A third requirement is that the language provide the computational, logical control and file-handling capabilities necessary to permit the variety of techniques which are encompassed by CAL. An effective course-authoring language is expected to support modes of operation which include adaptive tutorial instruction, drill and practice, operation as a problem-solving tool, simulation, information retrieval and operation in support of management of individualised instruction. Most applications incorporate more than one of these modes and to concentrate on any one at the expense of the others in the design of the language would limit its range of application.

The fourth main requirement is for the language to have a structure which will permit ease of learning and use by the CAL novitiate. Many course designers will not have an extensive computer science background and should not be expected to have to occupy themselves with details which can be performed for them by the system. Thus the language should incorporate the features and a structure which permits the course author to concentrate on the functional aspects of couseware design.

Characteristics of NATAL-74

NATAL-74 is a block-structured language which incorporates three fundamental elements: UNITS, PROCEDURES and FUNCTIONS. The UNIT is the element through which the user program communicates with the student. It may be considered as carrying out one complete instructional transaction. The UNIT provides for the display of information, acceptance of input from specified devices, editing of input data, categorization of responses and implicit branching. The Display Sublanguage which is available in the UNIT provides flexibility in the formatting of alphanumeric information and the construction of complex graphic presentations. The UNIT has access to system general functions, edit functions and graphic functions and permits a highly complex exchange of information to be specified.

Program control, or instructional strategy, is embodied in the PROCEDURE which provides data gathering, data processing and logical branching capabilities. The PROCEDURE assembles information required by the UNIT, processes information generated by student responses, controls the sequence of instruction and maintains a record of program operation. A PROCEDURE may call other PROCEDURES or UNITS, allowing a powerful and flexible hierarchy to be constructed out of independent modules. The structure of a NATAL-74 program is illustrated in figure 1.

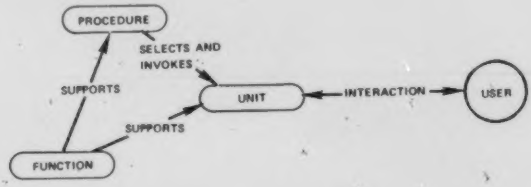

Figure 1
NATAL-74 STRUCTURE

NATAL-74 Implementations

The initial implementation of NATAL-74 is now running on the DECsystem-10 at the National Research Council. This implementation was undertaken with two main requirements in mind. The first was to get a NATAL-74 system in operation as soon as possible in order to start testing the language and get feedback from the organizations participating in the NRC CAL project. In response to this requirement, the decision was taken to avoid duplicating features in the NATAL-74 system which were provided by the DECsystem-10 monitor. Thus the implementation relies on the monitor for file-handling, user scheduling, and inter-process communication. The second requirement was to undertake the implementation in such a way that it could be transferred to other machines with minimal effort. It was in response to this second requirement that BCPL was chosen as the implementation language and an attempt was made to avoid a high degree of dependence on features special to the DECsystem-10. There is obviously a certain amount of conflict between the two requirements and where system dependent features were introduced into the implementation they were to be identified to accomodate the migration of the system to other machines.

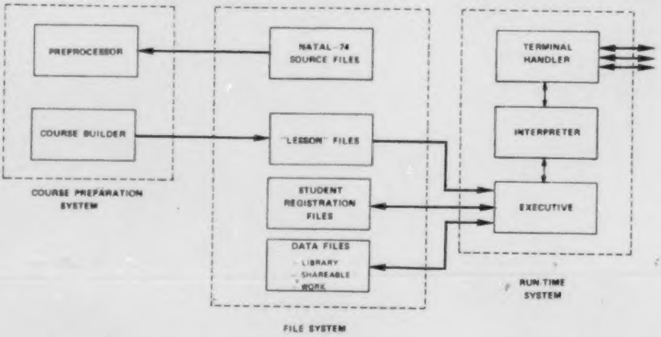
PREPROCESSOR
COURSE BUILDER
COURSE PREPARATION SYSTEM
NATAL-74 SOURCE FILES
"LESSON" FILES
STUDENT REGISTRATION FILES
DATA FILES
- LIBRARY
- SHAREABLE
- WORK
FILE SYSTEM
TERMINAL HANDLER
INTERPRETER
EXECUTIVE
RUN TIME SYSTEM

Figure 2
IMPLEMENTATION COMPONENTS

The implementation consists of three subsystems as illustrated in figure 2. The NATAL-74 source code is compiled into an intermediate language code by a preprocessor which also indicates errors in the user program which can be detected prior to execution. The preprocessed modules are assembled into courses by a builder program which carries out the functions of a linking loader. The run-time subsystem is made up of the interpreter, which executes the intermediate language code, the terminal handler, which supports the display sublanguage and links the subsystem to the user terminals, and the Executive, which links the subsystem to the host computer and controls access to shareable resources such as course variables and files. During the course of the implementation, no changes were to be made to the specification unless it could be clearly shown that there was an inconsistency which had to be corrected, that the change would produce a significant saving in implementation cost or complexity with no functional change, that the specification deviated from widely accepted practice or that the specification did not meet a demonstrated user requirement. No changes were introduced simply to "improve the language". In other words, a concious effort was made to avoid redesigning the language during the implementation phase. Within these general groundrules, some changes were found to be necessary, but in terms of the overall specification, the total change has been relatively small. The areas of the specification most affected by changes are those dealing with graphics capabilities and file handling.

The implementation at present includes little in the way of what might be designated as author support facilities. In way of an example, to pass from a NATAL-74 source program to an operating course, the author must first create his source code program using one of the editors provided within the DECsystem-10 monitor, preprocess the source code modules using the preprocessor, then load them into a course using the builder before he can run the program. Much in the way of support facilities remains to be added to the system to relieve the user of the tedious detail involved in assembling, debugging and running a course. However, while the present support facilities are less than ideal, the NATAL-74 system is operational on the DECsystem-10 and is sufficiently complete that it can be used for effective testing of the language.

In April 1977, work started at the University of British Columbia (UBC) on the adaptation of the NATAL-74 implementation to the IBM 370/168 which runs under the Michigan Terminal System (MTS). The initial part of this undertaking concentrated on the run-time system. The major problems encountered in the transfer took the form of differences between the DECsystem-10 and the UBC versions of BCPL, and machine-dependent parameters in the interpreter and terminal handler which were not sufficiently well isolated and/or documented. As a result of the UBC project the machine-dependent elements of the implementation are now clearly identified and transfers to other machines will require considerably less effort.

Preliminary Evaluation

With a view to assessing the performance of NATAL-74 and its implementation in a variety of modes of operation, several CAL programs have been recoded from their original versions. These include CARE-1, written in Coursewriter-II at the Pennsylvania State University. This program provides a practical example of a tutorial mode application in which there is extensive use made of multi-mode communication devices. MACMAN, a simulation of the heart-blood circulatory system developed at McMaster University has been recoded in NATAL-74 from its original FORTRAN-IV version. LUNA, a dialogue making extensive use of graphics, from the Physics Computer Development Project at the University of California has been partially recoded in NATAL-74. The work on this latter program has been particularly valuable since it brought to light a number of weaknesses in the graphics facilities in the original NATAL-74 specification. These have since been corrected and it is now possible for the course author to work in his own coordinate system, using the computer terminal to display all or part of the graphic work space he is using.

While existing CAL programs provide a good source of material for testing various aspects of NATAL-74, they have the disadvantage that often the design of the original program reflects limitations imposed by the original programming language and full advantage is not taken of the facilities offered in the higher level language. Thus the evaluation of NATAL-74 also requires use of the language in the development of original application programs. Within the NRC laboratory, several programs have been developed which illustrate the use of NATAL-74 in a number of application areas. A program has been written, for example, to illustrate the use of the computer in accessing the various documents which are required in commercial trading with countries throughout the world. This program drew heavily on the block structure, file handling and the graphics capabilities of NATAL-74. Another example is provided by a program designed to support the preparation and delivery of instructional and drill sequences used in a learner-controlled approach to second-language learning. Again, the block structure and file handling capabilities of NATAL-74 played an important role in the program design.

The first program development in NATAL-74 outside of the NRC laboratory took place at the University of British Columbia (UBC). During the first quarter of 1977, a single video display terminal at UBC was linked to the NRC computer to permit "field trials" with students in the Faculty of Education. The academic focus for this work on NATAL-74 was provided by a project concerned with the diagnosis of computation and algorithm errors made by children when learning to add, subtract, multiply and divide.

Education-491

Education-491, "Computers in Secondary Education," is an elective course at UBC open to education students in their final year. 491 students usually enrol for the purpose of preparing themselves to teach Computing Studies in secondary schools. The course covers all aspects of the use of computers in secondary education, with emphasis on the teaching of Computing Studies and interactive applications (including CAL) in the schools. Students are required to have at least one full course in Computer Science as a prerequisite, but most have more background than this. It is known to be a "heavy" course so that it is reasonable to assume that most students are motivated and interested in computer applications in education.

The entire 491 class was taught the NATAL-74 language in four fifty-minute classes. Students were given a choice between doing an assignment using NATAL-74 or using a more limited CMI system (TAIM). The NATAL-74 assignment was considered to require more computing expertise because students would have to learn how to interact with the DECsystem-10 Monitor and the SOS Editor as well as learning how to construct, compile, and execute routines in NATAL-74. Furthermore, NATAL-74 would be available for only three months, and during the second month all students would be away doing student teaching. Six students were permitted to do the NATAL-74 assignment. All had a B.Sc. (or equivalent) with a major or concentration in Computer Science.

The Task

The task chosen was to construct Drill and Practice programs in addition, subtraction, multiplication and division of whole numbers and decimals. The drill exercises were generated so that they proceeded generally from easy to hard, and presented the variety of combinations of number length, carrying, and presence of zeros, that can occur in these operations; all under program control. The intention was to be able to generate basic operation problems of any particular type so that these could be provided for drill on that precise aspect of the algorithm and so that if a student consistently got such questions wrong, the portion of the algorithm he was misapplying could be specifically identified. The question generation routines were constucted as independent modules so that they could later be incorporated into more general drill and/or diagnostic programs. The diagnostic programs could then have appropriate remediation material added so that a comprehensive self-contained basic operation testing and teaching package for whole numbers and decimals could be built-up.

Developing The Courseware

The instruction on NATAL-74 was given during the month of January. Following the lectures, the students who were engaged in the NATAL-74 assignment were assembled to discuss the general approach to the problem. It was decided to divide the work into six distinct projects so that a minimum of interaction would be required between the students. The six projects were:

1: Addition of Whole Numbers.
2: Subtraction of Whole Numbers.
3: Multiplication of Whole Numbers.
4: Division of Whole Numbers.
5: Addition and Division of Decimals.
6: Subtraction and Multiplication of Decimals.

It was felt that the drill programs could be constructed as independent routines which could then be controlled by a higher-level PROCEDURE written later. Some time was spent initially designing the parameter lists for each of the routines and designing the question/response format for each of the different question types. The students, knowing the way in which their routines would be called, the standard format of the drill questions, and their specific subject area, could then proceed with the development of their routines independently.

Each student constructed a single UNIT for each of the question formats they would need. Some constructed General Functions to generate the types of operands they required - others generated their operands in their controlling PROCEDURE. Each student created a single controlling PROCEDURE for each operation.

As mentioned earlier, the NATAL-74 System was available for only three months. The first month passed while students learned the NATAL-74 language, explored the task and designed the question formats and calling protocols. During the second month students were engaged in student teaching. This left only the month of March to learn to use the DECsystem-10 Monitor, the SOS Editor, the NATAL-74 system procedures, and to design, code and test their NATAL-74 routines. Of course students had other duties at this time with 491 being only one of the courses they were taking.

During the coding of their NATAL-74 routines, students encountered a number of problems. Most of these had to do with learning to use the Monitor and Editor. Some arose because of discrepancies between the Author Guide definition of NATAL-74 and the actual implementation. At that time the NATAL-74 implementation was incomplete. On several occasions, because of missing functions, students had to re-design their algorithms and then re-code them.

Even with these handicaps, all students were able to complete their assignments. Further, the Drill and Practice exercises they prepared were of high quality. There were no significant problems caused by "modularizing" the student assignments. Students were able to proceed independently in designing their algorithms for question generation and control. Standardizing the calling protocol (parameter lists) for each question type and the general question format was the only common consensus required. Lower level design did not demand further communication between the course authors.

Results

A specification has been developed and used as the basis of a running implementation of NATAL-74. While work on the implementation and initial testing has brought to light some weaknesses in the original "paper" specification, this was to be expected and modifications have been made which correct the deficiencies. While the specification has not yet reached the stage of a firm standard in that additional changes are expected to result from further testing, it should stabilize over the next few months.

The NATAL-74 projects which have been undertaken to date have demonstrated the possibilities of the language in CAL applications which include tutorial, drill-and-practice, simulation, and prompted authoring techniques. A good level of adaptability to various terminal types has been achieved. The DECsystem-10 implementation supports hardcopy terminals such as the Teletype and Multiwriter, alphanumeric display terminals such as the Lektromedia-103 and the Vucom-I and III, multi-media terminals such as the Lektromedia-120 which incorporates a defineable character set, slide projector, audio output and graphic input in addition to the conventional alphanumeric display capability, graphic terminals such as the Tektronix 4012 and 4051 and an experimental graphics terminal developed in the NRC laboratories. Using the automatic formatting capabilities of NATAL-74 for alphanumeric displays and the graphics function capabilities of the display sublanguage it has been shown possible to run programs on functionally equivalent terminals with no changes required on the part of the user.

The use which was made of NATAL-74 in the Education-491 class was limited to the preparation of drill and practice routines, but clearly demonstrated that the language could be quickly learned and applied to produce practical CAL materials. The capability of "modularizing" NATAL-74 code has a number of advantages. After preliminary interface agreement, authors can proceed independently to define their routines. In the 491 trials, the student's primary job was to constuct one or two UNITS and a controlling PROCEDURE. They did not have to concern themselves with how their routines would eventually fit into the whole course. Yet the modularization permits an easy assembly of the various routines into a cohesive whole. Education-491 students found the syntax of NATAL easy to master and use.

Conclusions

While several features remain to be incorporated in the NATAL-74 implementation and some additional specification changes are to be anticipated as a result of continued testing, the results achieved to date suggest that NATAL-74 meets the programming language requirements for CAL applications and can be an effective vehicle for the transfer of courseware between installations. The results support the continued investigation of NATAL-74 implementations on additional machines, including the development of mini-computer based delivery systems.

References

1. ACIT Working Panel. "A Functional Specification for a Programming Language for Computer-Aided Learning Applications", Report No. NRC-13659, Associate Committee on Instructional Technology, National Research Council, Ottawa 1972

2. Zinn, K.L. "Comparative Study of Languages for Programming Interactive Use of Computers in Instruction", EDUCOM Research Memorandum RM-1469, 1969

3. Westrom, M.L. "National Author Language NATAL-74 Specification Manual", Report No. NRC-14245, Associate Committee on Instructional Technology, National Research Council, Ottawa, 1974

CAI TERMINAL CHARACTERISTICS

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The bewildering number of available terminals which are offered to CAI users presents a rather formidable problem: which should one choose? As each distributor generally sells only one product, comparative information is difficult and time consuming to obtain. This article surveys what appear to be evolving standards for terminals. The usefulness of these terminals for CAI purposes is discussed, together with the best known prototype exhibiting the particular feature.

Based on different technological requirements, terminals may be roughly classified into the following five categories:

A. Typing terminals

B. Simple CRT terminals

C. Semi-graphic CRT terminals

D. Full-graphic CRT terminals

E. Video display terminals

The characteristic technology, and advantages and disadvantages for each of these five classes of terminals is discussed below.

A. Typing Terminals

The natural choice for the first CAI terminals were already existing telecommunication machines such as the TELEX Teletype. Its low cost made it an attractive choice for a terminal, but there are some who claim that the availability of this type of terminal retarded CAI for at least ten years. The high noise levels and slow printing speeds of typing terminals such as the Teletype or the IBM 2741 have led educators to frown on CAI as a classroom tool (except in schools for the deaf), frequently abandoning CAI as a feasible alternative method of instruction in the process.

These early limitations of typing terminals have been largely overcome. Modern typing terminals, such as the dot printers, or ink-jet printers, operate nearly noiseless, print faster than reading speed, and are available at low cost.

1. Technical Characteristics

a. Dot printers have a small printhead featuring a single column of vertically arranged wires--usually seven in number. Upon moving the printhead across the paper, these wires are fired at appropriate times to formulate the character images. Since the printhead features only a single column of wires, it must move across the character space for printing purposes. Most dot printers print both forward and backward, thus creating an erratic movement pattern for the printhead when data is entered from the keyboard.

Dot printers can achieve printing speeds in excess of 100 characters/second. This is much faster than average reading speed. Therefore, lengthy material can be printed without having students wait excessively for the printer to finish.

Theoretically, dot printers are capable of producing full graphics. In practice, this has not been achieved for two reasons. (1) They generally have only one or two hard-wired character sets, which do not allow the printing of configurations needed for graphics. (2) The column of print-wires does not extend over the space between print-lines; hence, continuous vertical displays can not be drawn. An example of a dot printer is the DECwriter.

b. Ink-jet printers pass a small jet of magnetized ink through magnetic deflectors which deflect the ink-jet such that it "writes" the character. Since this printer has almost no moving parts, it is fast and noiseless, giving a print quality superior to the dot printer. Some available ink-jet printers are presently manufactured by IBM.

2. Advantages of Printing Terminals

The availability of hardcopy output has frequently been cited as a major advantage of printing terminals. This is likely so where developmental work is done: a trace of the work may be important. When doing CAI, the CAI system records a trace of each student's progress through a course. Experience has shown that hardcopy output of completed coursework is generally "filed" away. Thus, it is of small importance in CAI work. Students should experience the CAI system like a library resource: the courses they have taken via CAI are waiting to be re-taken as often as desired--like the books in the library are waiting to be read. This alleviates the need to purchase the library books, or to take hardcopy of a course.

3. Disadvantages of Printing Terminals

With the elimination of slow operating speed and the noise factor, the disadvantages of printing terminals for CAI have become marginal. One could cite ongoing operating costs, such as paper, ribbons, and ink as being a disadvantage in comparison to CRTs. Another disadvantage might be the lack of rapid scrolling which can be used on CRTs to skip unwanted portions of a course.

Perhaps the major restriction of typing terminals is that they are exclusively suited for presenting written material. A student must be able to read and type to operate the keyboard in order to interact with a typing terminal. While auxiliary devices, such as a slide projector or tape recorder, can be operated concurrently to allow graphic or audio support, they often add a fair level of operating complexity which distracts from learning.

B. Simple CRT Terminals

The term "CRT terminal" has been commonly accepted to denote all display panel devices, even though some do not use a Cathode Ray Tube. For convenience, it will be used in this fashion here.

1. Technical Characteristics

The most commonly available CRTs fall into the category of "simple CRT terminals." They are generally capable of displaying about 24 lines of 80 characters, for a total of 1920 characters. Most CRTs need to be refreshed, that is, similar to a TV set, the image on the CRT must be re-written several times per second to avoid dimming or flicker. Therefore, CRTs usually have a local memory, or buffer, which holds all the information to be displayed on the screen. This buffer is loaded by the computer with the information to be displayed, and on the next refresh cycle, the content of the buffer is read and shown on the screen. The information is passed through a character generator which translates the bit-structure of the buffer into the appropriate character image, and displays it on the screen in the appropriate character rectangle corresponding to the buffer location.

In general, each of the buffer locations is addressable and can be selectively modified, allowing for such effects as blinking through periodic erasure and re-display, or changing portions of the display. While theoretically an eight bit buffer structure would permit the display of up to 256 different character images, this would necessitate an extensive character generator. Frequently, character generators in available terminals provide for no more than 48 different symbols, with additional ones being available only at extra cost.

The dominant characteristic of the "simple CRT terminal" is a hard-wired character generator. In other words, the available character set is fixed and can only be changed by physical modification of the terminal. One could, of course, have several character generators installed, and select the appropriate one either under program control, or by means of a switch on the terminal. This would be similar to changing the typeball on a Selectric typewriter, and would be required if one wanted to use the terminal for programming in languages such as APL. Since character generators are rather expensive, it would not be reasonable to provide a large number.

2. Advantages of Simple CRT Terminals

As compared to printing terminals, CRTs are perfectly noiseless. Information can be displayed as fast as the computer and transmission lines permit. Rapid scrolling of data files, or course material is possible. Pointing devices can be attached which permit the student to point at a menu of choices displayed on the screen rather than respond only via the keyboard. This can greatly speed up passage through a course as there is no need to look away from the screen. CRTs are relatively more maintenance free than printers, requiring no paper, ribbons, or ink.

3. Disadvantages of Simple CRT Terminals

Due to their limited character set, simple CRTs feature the same disadvantages as printers with regard to graphic displays: they simply have no graphic capability. Students must be able to read as all information is presented in written format.

C. Semi-Graphic Display Terminals

There are two characteristics which differentiate a semi-graphic CRT from a simple CRT: it must have a programmable character generator, and the rectangles used for displaying characters must have adjacent boundaries with no intervening blank space. If these two conditions are met, one can assemble line drawings where each line segment running through a character rectangle has been defined as representing a character. The first commercially available prototype of such a terminal was attached to the IBM 1500 CAI system.

1. Technical Characteristics

Since the smallest addressable space on the screen is a character rectangle, only graphics composed of a defined pattern can be represented. Each smallest part of the graphic picture is the size of a character. Note that on simple CRTs and dot printers, the character is generally embedded in a 7 x 5 dot matrix rectangle. On semi-graphic CRTs, the character rectangle is customarily a 12 x 7 dot matrix. The character still consumes only about 9 x 6 of this space, with the remainder being used to create the boundaries around the character. However, these boundaries can be filled in as required when creating continuous lines for graphic displays. Hence, these terminals permit the showing of uninterrupted lines through the design of special characters which can be loaded under program control into the customary character generator to replace some or all of its content.

2. Advantages of Semi-Graphic Display Terminals

The capability to replace character sets under program control adds a tremendous flexibility to the terminal for CAI purposes. This flexibility is so important for all but verbal presentations that terminals without this feature can really not be called "CAI" terminals. The replaceable characterset provides a major stepping stone in making a terminal useful for CAI.

3. Disadvantages of Semi-Graphic Display Terminals

Obviously, additional costs are involved. Also, a fair amount of software is required to facilitate the proper design of special characters on the screen. This software is now generally modelled after the first such package which was developed and implemented at the University of Alberta on the IBM 1500 system.

D. Fully Graphic Display Terminals

1. Technical Characteristics

The dominant characteristic of a fully graphic terminal is that not only can one address character rectangles, but also each dot on the screen is addressable. Given supportive software, this allows the drawing of lines between any two dots, either straight or curvilinear, to generate any desired drawing. The best known example of such a fully graphic terminal is the PLATO terminal.

2. Advantages of Fully Graphic Display Terminals

Terminals such as PLATO satisfy the most demanding display request imaginable. Supporting software exists to draw characters of any size or shape at any angle of display. Lines and circles can be created via software routines to compose complex pictures. Processing is sufficiently fast to create an impression of slow motion, such as a growing snowflake. The true potential of this type of terminal has only been scratched at this time since many teaching techniques making full use of this technology have not yet been invented. It is capable of handling the most imaginative learning applications.

E. Video Display Terminals

The video terminals are one step beyond the full graphic terminals: apart from displaying alpha-numeric and graphic information, they can be used to show motion pictures, usually in full color. In fact, most video terminals use existing TV technology. The digital and graphic display information from the computer is simply mixed with output from a video source (e.g. video tape player) to create the desired screen effect. An example of a system using this technology is TICCIT.

1. Technological Characteristics

A fairly large amount of special hardware is required to operate a video CAI system. However, it is the ultimate in interactive, automated teaching. Programming is relatively easy as the information required by the system can be entered in pictorial form, that is, a frame of information can be treated like a picture, and can be stored on a random access video disk or other video storage device. Video films can be interspersed at appropriate points in the program for demonstration of learning principles or other effects. Presently, these films would need to be retrieved from a video library and loaded onto video tape players whose output signals can be mixed with the appropriate terminal signal. However, new laser beam technology promises to simplify this problem in the near future.

2. Advantages of Video Display Terminals

The overwhelming advantage is the possibility of designing curriculum with almost no restriction. Whatever the eye sees or the ear hears in the real world can be replicated by a course author on a video terminal. Note, however, that the TICCIT system is not an example of a system permitting this kind of authoring capability. Authoring freedom on TICCIT has been purposely reduced to simplify authoring and reduce system overhead.

Another advantage is the low cost. Since video terminals use mass-produced TV-technology components, they are much less costly than any of the other types of terminals.

3. Disadvantages of Video Display Terminals

One might wonder why the low cost and enormous flexibility of the video technology has not made it the automatic choice of the educational community. There are two reasons: first, CAI is most frequently done in "piggy-back" mode, that is, it is added to a computer which exists and has been cost-justified for other purposes. A video-based CAI system needs a lot of dedicated special purpose hardware which can not be used or cost-justified for other purposes (e.g., administration). Second, the home television set has trained TV viewers to expect rather sophisticated and professional presentations. It would be quite a challenge for educators to match the talent and creativity of the entertainment industry when designing courses for video display terminals. Also, a considerable amount of money would be required for this design work.

SUMMARY

Five types of commonly available terminals have been discussed. These were:

A. Typing terminals, capable of displaying alphameric information only, with hardware character generators.

B. CRT terminals, capable of displaying alphameric information only.

C. CRT terminals with programmable character generators, capable of displaying pre-stored graphic information.

D. CRT terminals with the ability of addressing each point on the screen, capable of displaying generated graphic information.

E. Video terminals capable of displaying moving pictures in addition to full graphic capability.

The terminal types A and B are the most frequently found terminals. Since they can only display alphameric information, their suitability for CAI is relatively limited. Type C would appear to be a minimal requirement for a CAI terminal. It permits presentations with predefined graphic displays to enhance understanding. Type D is the most sophisticated CAI terminal presently commercially available. Its technology is fully developed. A somewhat restricted version of Type E is now in production (TICCIT), while a less restricted version is at the operational stage at the University of Waterloo in Canada. Substantial enhancements of Type E terminals can be expected with video disk storage based on laser technology.

IMPLICATIONS

Since this paper is intended to provide an overview of the most important terminal characteristics, many details have been left out. These are, however, generally minor when compared to the major classifying characteristics presented here. A prospective terminal buyer not only needs to know his own intended applications and the terminal characteristics required for these applications, but also the amount of course material which is already available to him from other sources. While some adaptation of course material is almost always necessary, it is much easier to adapt a course which has already been developed and debugged, rather than to start from scratch to re-invent the same wheel. However, there are degrees of difficulty. A course making use of a pointing device can be modified with relative ease to work on a similar terminal without such a device, but a course written for a Type C terminal can not be adapted to a Type B or Type A terminal. This limitation must be kept in mind when deciding on suitable terminals.

ELECTRONIC COMPUTERS FOR SLATE-BOARD SCHOOLS:
AN ETHNOGRAPHIC PARALLEL TO STEEL AXES FOR STONE-AGE MEN

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Where will education be in 1984? Education is presently frozen in the technology of the past. However, a 1972 Carnegie Commission Report suggests that the education industry is currently sitting on the brink of its first technological revolution in five centuries--the revolution of the new electronics. According to this report, three major revolutions in education have already taken place.

The first revolution in education was ushered in with the introduction and adaptation of the written word; the second was the use of textbooks that followed the invention of moveable type. The third revolution came about as a result of industrialization and centered on the implementation of universal public education. Today, we are attempting to attain the goal of customizing education to individual needs on a universal basis, e.g., laws on "mainstreaming." The fourth revolution can facilitate this goal by introducing modern technology associated with electronic communication systems and electronic data processing systems.

Currently, however, few educational institutions have availed themselves of this opportunity. A Federal Commission on Instructional Technology reported that the impact of technology upon American education in 1969 was no greater than the impact the automobile had made on American life before the Model T (Cunningham, 1977). This paper has attempted to deal with general concepts of planned culture change that could reduce the education industry's resistance to technological change. Ethnographic parallels were utilized to demonstrate the desirable use of the principles of culture change and technological innovation in the culture of our schools.

Education as a Culture

The school, and professional education in general, can be viewed as a unique culture with its own defined field of ethnology. Therefore, the success of a deliberate introduction of radically new technology into this culture will depend, to a large extent, upon a full understanding and consideration of that ethnology. Innovators interested in promoting computer based education systems within the education culture may be more successful if they avail themselves of the principles of planned culture change generated by applied anthropology.

Kroeber (1963, p. 94) states that ". . . most of what is in any culture was produced outside of it . . ." Stiles and Robinson (1973) add that change in education is typically generated from outside rather than from within. Moreover, anthropologists have shown that technical know-how is imbedded in cultural systems; and that patterns of beliefs and behavior that make up such systems can act as either sanctions or barriers to technological change (Niehoff, 1966). A rather dramatic example of how changes in technology can have devastating effects upon the social system is provided by a study of the Yir Yoront, a tribe of Australian aborigines (Sharp, 1952).

The Cultural Significance of a Tool

The Yir Yoront lived in almost total isolation from Western culture until the early 1900's. A stone-age technology existed. Only adult males could make and own axes. Stone for the ax heads was not available near the coast. Therefore, an elaborate trading system was established with inland tribes many miles to the south. Stingray spears made near the coast were taken south and stone ax heads were brought north. Each male Yir Yoront developed trading partners with members of the inland tribes. Most exchanges took place during very large inter-tribal meetings that were attended by hundreds of men from many tribes. Various initiation and totemic ceremonies provided a festive atmosphere at each of these meetings; but the trading of spears for stone ax heads was an important part of the motivation for the inter-tribal meetings.

For the Yir Yoront, the ax was a symbol of masculinity, status and authority. The ax was held in such high regard because all members of the tribe, men, women, and children, had to use the axes in their daily tasks. The women and children, however, were required to borrow their axes from the men. The borrowing followed kinship lines and established the male head of the family as the dominant figure. This practice defined and maintained a deeply imbedded system of status, sex and role inequality. The ritual established by this custom maintained the status quo for the Yir Yoront and provided an era of stability that this culture enjoyed for hundreds of years. That stability was shattered by the arrival of missionaries who brought with them the tools and cultural ideas of a new age.

One of the tools that the missionaries brought with them was the steel ax. However, the distribution of the steel axes by the missionaries was done indiscriminantly. Women and children ended up owning most of the steel axes. This meant that an adult male who wanted a steel ax had to borrow it from a women or a child or had to obtain his own steel ax from the missionaries. Unfortunately for the male Yir Yoront, steel ax giving at the mission was done rather capriciously. This condition strained traditional sex, age and kinship roles; it blurred leadership patterns, weakened traditional trading practices, and reduced attendance at inter-tribal ceremonies.

The steel ax also affected the Yir Yoront belief system. This was inevitable since every element of their culture was accompanied by a myth which explained its existence. No one could concoct an acceptable myth about the steel ax. Therefore, since the steel ax

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couldn't be made to fit into the tribe's totem, doubt and confusion developed over other aspects of the belief system. This confusion, combined with other impositions introduced by the Westerners, forced the Yir Yoront into a set of conditions under which the stone-age culture could not long survive.

The Cultural Significance of Computers in the Classroom

We are not interested in providing steel axes for stone-age men. We are interested, however, in providing electronic computers for schools whose technological development may have been arrested at the slate-board stage. Schools have made a slight change from slate and chalk to books and pens, but the underlying social organization of many schools rests on assumptions that act as barriers to the introduction of computer based education. As in the case of the Yir Yoront men, most present-day classroom teachers who want the new technology, educational computing, must exchange their old technology of lesson preparation and delivery for a new method. The old technology provides independence, self-sufficiency and autonomy. The new technology tends to make the teacher dependent and subordinate to computer operators, programmers, and machines; technologists advise teachers as to what can or is currently being done and what is the next most probable instructional move. Indirectly, the teachers of computer-taught students are asked to relinquish old myths about teachers and teaching (Allen, 1971; Stiles and Robinson, 1973, p. 265). Teachers in slate-board schools were dispensers of information and drill masters. These are still the dominant images when one is asked to think of teaching. For most people, images of teaching involve the teacher lecturing to or interacting with students. Consider, also, which teachers have tended to receive the most recognition: the charismatic performer; the loveable mother figure, the exciting group organizer. Each type is secure in the knowledge that the role he plays is certain to bring him success. An innovation such as educational computing raises questions about established myths concerning the role of teachers. It should be no surprise that many school personnel believe that computers may be good for other students but not for their own.

Patterns of behavior which have paid off in the past are going to be maintained until expectations of better payoffs have been envisioned (Nordskog, 1960). Even if the new technology is accepted, it may only be used for the same old things or be reduced to doing tasks that are mirror images of ancient practices. For example, it is interesting to note that the steel ax was used only for those tasks for which the stone ax had been used. The Yir Yoront's savings in time and effort were spent sleeping. Currently, educators have utilized the savings in instructional time that educational television has provided in a similar manner. Consider how television originally was used by the education industry; it was perceived as a way to permit the "master teacher" to lecture to many more students than was previously possible through live sessions. Television presentations permitted the regular classroom teacher to maintain discipline, take a coffee break, or, as did the Yir Yoront, sleep. Thus, the achievement gains realized through instructional television were minimal. In addition, the development of instructional technology was minimal. For example, think of how television was used to do what previously had been impossible or very difficult to accomplish in a regular classroom with traditional equipment. Very few examples come to mind. We can cite:

1. feedback for various performances in the arts,
2. feedback for athletics,
3. microteaching, and
4. views of ongoing surgery and other detail activities where a lens can zoom in for close-ups.

Unfortunately, the above types of applications are the uncommon uses of instructional television. The paucity of this kind of use indicates that established practices and assumptions about teaching and learning common in the education culture have inhibited and thwarted the diffusion of technological innovation (Kroeber, 1963, p. 223). Innovation based upon computer technology could suffer the same fate.

A humorous but sad tale is told of a group of Southeast Asian villagers who were given powdered milk to help solve their nutrition problem. "The villagers who had never used milk before reportedly used the powdered milk to make lines on their soccer fields" (Niehoff, 1966). It appears that consideration had been given only to the physical distribution of the new technology, i.e., powdered milk. Little, if any, consideration had been given to the cultural factors involved. A social-cultural approach to planned cultural change would alert one not only to the probability and source of resistance, but also to the modifications that might occur as a result of acculturation (Kroeber, 1963; DuBois, 1961).

A Social-Cultural Model for Planned Change

Deliberate social change involves a plan, a procedure for moving from an existing way of doing things to the integration of a new idea or technique. As part of the plan, one must identify the major forces that impinge upon the innovation. Niehoff (1966) has suggested that planned innovation has only two major forces which act upon it. The first force comprises the techniques used by the innovator to achieve adoption of an innovation. The second force includes the behavior of the recipients toward the proposed innovation.

Fortunately, the techniques of the innovator appear to have far more influence upon the success of an innovation than do the characteristics of the recipients. This means that good planning and careful control can raise the probability of successful integration of an innovation into the culture. However, it will be necessary to give attention to the several factors that comprise these two major forces affecting planned innovation.

Niehoff has identified seventeen kinds of factors which impinge upon the implementation of an innovation. Six of the factors appear to be primary process variables, and we have separated them into characteristics of the innovator and characteristics of the recipients of the innovation.

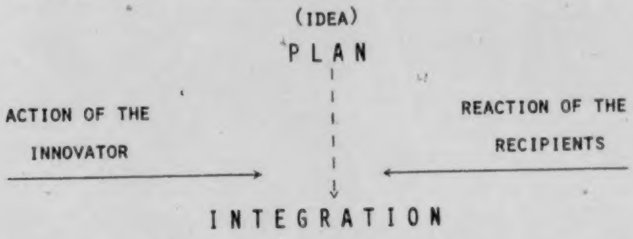
First, the characteristics of the innovator:

1. the methods of communication used by the innovator;
2. the type of participation the innovator obtains from the recipients; and
3. the manner in which the innovator utilizes local culture and adapts the innovation to existing cultural patterns.

Second, the characteristics of the recipients:

1. whether or not the recipients have an initial felt need;
2. whether the recipients perceive any practical benefit in adopting a change; and
3. whether the recipients' traditional leaders are brought into the planning and implementation of the process.

The reader may find that other models of planned change are more appropriate for his own particular problem. Many have been offered (Schaller, 1972; Bennis, Benne and Chin, 1961). Niehoff's was selected as a guide for our discussion. His analysis of anthropological studies indicates that almost all of the successful change projects accounted for all of the characteristics listed above in the innovation plan. The following model (Niehoff, 1966, p. 11) may be of some use in conceptualizing these factors.



Methods of Communication

The application of Niehoff's model to the implementation of computer based education (CBE) is rather obvious. For example, in the area of communication, the use of demonstration, personal contact, and feedback are quite important.

Initially, an effective demonstration of an innovation such as CBE can provide immediate and dramatic proof of the efficacy of the proposal. Perhaps the innovator should arrange for educators (the recipients) to learn about CBE via CBE rather than by means of lectures and films.

Secondly, personal interaction with those who must adopt the innovation puts the innovator into the social system of the school, and, therefore, must be part of the innovator's plan. Personal interaction permits teachers and administrators to raise questions and express feelings that might not be communicated openly in large formal groups. One of the authors has found that parties held off the school grounds in "neutral" quarters creates an environment that promotes honest communication. At such times, school personnel have confided privately their personal fears as well as their favorable inclinations. These feelings would never have been expressed in a more formal setting.

A third concern of utmost importance is the establishment of a feedback channel. In the case of many innovations, this is difficult to achieve. Fortunately, feedback is a built in part of a CBE system and is not an unfamiliar idea to the computer specialist. However, feedback is also critical in its social sense if the innovator is to know how the school personnel are reacting to CBE. It is by means of this feedback that the progress of the innovation plan can be assessed. Parties, computer messages, personal visits, committee reports are all possibilities. Feedback helps one maintain the use of local language and reduces unnecessary use of technical jargon. One of the authors found that a teacher's guide for an elementary math program was not being read adequately. One section was entitled, "Control Functions." When this was changed to "Teacher Control of Instruction," it was read, and the teachers were much more satisfied with the program.

Participation of the Recipients

If school personnel, this includes administrators as well as faculty, do not participate in the CBE innovation plan, it is unlikely that they will continue with CBE after the innovator leaves. Participation by the recipients is a basic index of their commitment. Barth (1967) insists that the allocation of time and resources is the critical variable. Decisions about the allocation of time, labor, money, physical resources, and social behaviors such as deference or ridicule make up the core factor associated with social or institutional change. Innovators should work toward gaining this kind of behavioral commitment. Both teachers and administrators must begin to allot time and resources to CBE.

One of the authors has been conducting a very intensive two-week summer workshop on CBE. Apparently, involvement in this workshop has contributed significantly to developing a commitment to foster CBE. It was discovered that in the last two or three years twelve school districts in our area had adopted CBE and maintained it a second year. Each of these districts had someone in attendance at one of the workshops. Two districts adopted CBE but did not maintain it a second year. Neither of these districts had any members in attendance at a CBE workshop. We need to discover other techniques for developing commitment that have this degree of success.

Utilization of Established Patterns

Innovators may either attempt to replace inefficient practices *in toto* or they may attempt to adapt old practices by grafting new practices onto them. Members of a culture, e.g., school personnel, will not willingly give up old practices until they are convinced that the proposed innovations will contribute to an overall gain for them. Complete replacement of a practice is more likely to be resisted than is the adaptation of that practice. Adaptation permits both old and new to compete on relatively equal terms. Replacement will occur automatically if it really does contribute to significant payoff.

For example, it would be almost impossible to have CBE immediately adopted as a complete replacement for classroom, teacher-led instruction. Human interaction, teacher-pupil interaction, will not be completely replaced, nor is it advocated here. The reaction of educators to terms and phrases connoting the replacement of teachers has been quite negative for some time (Tobias, 1966). It is possible, however, to convince teachers that CBE can be used effectively as a supplement to ongoing instruction for the purpose of improving competencies in basic skills or for checking the progress that students are making with classroom materials (Jamison, Suppes and Wells, 1975; Hirschbuhl, K., 1977). Furthermore, by facilitating the organization of small-group instruction, CBE may permit the teacher to play the traditional roles more effectively, i.e., permit the teacher to have more personal contact with the students.

It is interesting to observe and discuss the uncomfortable feelings experienced by many teachers the first time they find students learning without their help. Generally, we have found that teachers are unwilling to give up control of the teaching process to a computer program. They are much more willing to try to utilize CBE when computer programs permit them to decide specifically what the student will study or practice each day. They want this study tied directly to the instruction they are presenting that day. They are interested in drill and practice material, instructional management programs, and terminals located in their rooms. Sending the student off to some other part of the building is perceived as losing control of the student and his instruction.

Utilizing these and other traditional practices should not be viewed as an undesirable compromise by the computer advocate. Gibson and Nolan (1974) have identified four stages of computer growth in industry. Education is still at the first stage. After the computer has been integrated into instruction by adapting established practices, more effective and original utilization can be attempted with minimal risks. We shall give further consideration to the utilization of traditional practices when we discuss perceived benefits.

Felt Need of the Recipients

One of the most significant forces that impinge upon the recipients in planned change is the extent to which a felt need is present (Barnett, 1953). If a felt need is present, it will serve as a catalyst for motivating a search for a means of satisfying the need. The recipients' motivation may be indicated by the solicitation of help, i.e., a request for outside assistance in solving a local problem. Although this reaction generally indicates the presence of a need, the need may be one of seeking status or "getting on the band-wagon" and may result in short-term adoptions. Such outcomes are almost certain if those who are soliciting help are more interested in the material or prestige benefits brought by the innovator rather than the innovation itself.

One of the clues that innovators can use to determine the presence of a felt need is the extent to which a group has attempted to solve a problem by their own efforts without outside assistance. Recipients who have attempted to do some of the things that CBE is capable of doing more effectively have a strong motivation for change. They know the magnitude of the problem, and they have experienced unsatisfactory results with other techniques. This is a situation in which a CBE innovation is likely to result in a successful adoption.

Not all needs are overt. In some cases they are latent, and a needs assessment study must be conducted. The successful introduction of CBE within an institution may be dependent upon such a study. There is evidence that many educational institutions have common latent needs. National surveys indicate that certain classes of needs persist throughout most of the country (Gallup, 1976; DeCecco and Richards, 1975; Harnischfeger and Wiley, 1976).

Significant concerns of parents and teachers include behavior management, motivation, and achievement in reading, mathematics, and composition. All school adoptions of CBE in our area have occurred because of concern over achievement in reading and mathematics.

CBE hardware and software that draw from and simulate popular types of games, or which are in other ways intrinsically motivating for recalcitrant learners, would fulfill many of the felt needs. Such applications would exemplify the strategy of using established practices, since special techniques and provisions for the exceptional child are very common. Teachers are usually interested in finding ways to handle the exceptions, whether the child is unusually slow, fast, hyperactive, or withdrawn. CBE applications that address these needs may be more readily supported and adopted by teachers than programs designed for average pupils in nonsensitive academic areas.

Perceived Benefits

Once a problem has been identified, the recipients must perceive that 1) there is a sincere intent to solve the problem by means of CBE, 2) CBE is an effective method for solving the problem, and 3) that there is some benefit to the recipients for solving the problem with CBE. It is very important that the benefits the innovator perceives as significant are similar to the benefits the recipients perceive as significant. The perception of the recipients is often influenced by the results of previous attempts to deal with the problem or with innovation generally.

An example of how previous innovation attempts can cause educators to act or fail to act on a proposed innovation is given by Sarason (1971) when he discusses an attempt to gain an innovation's entry into a school. Sarason gave an introductory talk to the entire staff of a school system prior to the opening of school. He observed that this formal mode of communication resulted in negative reactions. It wasn't, however, until he established personal communication and feedback channels that he began to understand the perception of the school personnel.

Sarason concluded that the negative results arose from the following set of conditions. Participants had heard such talks at the beginning of the school year many times before. They reacted with, "Here we go again." The reason for this negative feeling was that services had been promised in the past, but either no one showed up or they came so infrequently that their help was valueless. Evantually, the outsiders who promised to help disappeared. It is not suprising that the innovators were "perceived as transients on whom one could not or should not depend." Sarason also discovered that the principals and older teachers resented the "outsiders." They believed that the administration respected and supported the outsiders to a greater extent than the insiders. Proposals originating from within rarely ever got to the discussion stage and were almost never implemented. In a more formal manner, Sarason hypothesizes that the ratio of proposals made to those implemented within an organization is a good indication of what will happen to new proposals in that organization. Thus, the success of an innovation originating from without appears to be a function of the success of previous attempts to innovate from within. This characteristic of a school or system may provide CBE innovators with a good measure of where their efforts have a fair chance of paying off.

The Sarason report represents the situation where the innovation is ignored because of perceived expectations. In other cases, the innovation might be opposed because of perceived threats. In a successful innovation plan, benefits of CBE can range from enhancement of one's career, convenience, novelty, self-improvement, status change, mental health, improvement in student behavior to student achievement. These perceived benefits must be weighed against perceived costs. The risk involved in disrupting survival techniques of school personnel must be taken into account by the innovator. Insecurity arising from budgets, community concerns, competition, or student discipline will reduce the recipients willingness to take chances. As we have mentioned earlier, teachers resent the idea of being replaced. They also resist changes that diminish their importance or alter their roles. Factors such as these will vary. Careful study of a particular school or system and the nurturance of open communication with the innovator should increase the likelihood of a successful CBE implementation plan. The plan should include a well-defined list of benefits that the recipients can compare to their perceived costs and risks. The plan should also include some systematic way of demonstrating progress or lack of progress during the implementation period.

Involvement in Local Leadership

The sixth major force affecting directed change is local leadership. If an innovator ignores the traditional leaders or chooses to associate with the wrong leaders, the chances for implementing CBE are quite small. As is the case in other social systems, educational leaders usually have strong vested interests in their jobs. Outsiders who propose change without securing prior approval are bound to be perceived as threats. There may be times when such influential leaders must be opposed; but they can never be ignored.

The traditional influence of board members, superintendents, and principals is easily recognized. Innovators should also consider the influence of resource teachers, supervisors, and union leaders who work with the classroom teachers on a day-to-day basis. If these persons have the confidence of the teachers, then they also must become supportive of the project.

It is generally conceded that the support of top administrative leadership is absolutely essential if educational innovations are going to be given a fair trial at lower levels of authority (Tope, 1965). Ashby (1974; Carnegie Commission, 1972) believes that utilization of the new technology by the top academic administrators is essential. He believes that the greatest single obstacle to higher education's acceptance of a leadership role in the implementation of CBE is the lack of institutional commitment. The responsibility for reversing this trend lies with the highest level academic officers and administrators. It may not be sufficient for them to give approval; it may be vastly more beneficial for the recognized leaders to employ various aspects of CBE within their own professional assignment. When administrators use CBE as part of their job support system, the faculty should be far more willing to accept CBE support in other areas. Without such an example being set by the leaders, faculty may become suspicious about the institution's commitment. Such suspicion is likely to leave only a few brave souls working for adequate implementation.

Innovators should not neglect the public. It is generally the case that education adopts changes only when public opinion and pressure cannot be ignored. ". . . change in education always is more political than professional, more impromptu than rationally derived . . ." (Stiles and Robinson, 1973). One of the authors arranged for a CBE demonstration which involved the assistant superintendent, principal, teachers, and parents. This resulted in the building principal and some faculty participating in the two-week summer workshop mentioned earlier. The progress of CBE in this school is better than in any other using our computer facilities. Here is an example of public, top administration, and principal support and involvement. Commitment and communication has been excellent. It is interesting to note that the assistant superintendent has recently retired. The new assistant is not as supportive and decreased interest and involvement is being noticed in the school. There is little doubt that the involvement of top academic leadership is essential.

Secondary Considerations

If initial success is obtained with the implementation plan, then some secondary factors must be taken into account. The innovator must be flexible. In order to deal with problems as they arise, a change agent must be able and willing to adjust plans in order to compensate for the unexpected. As the implementation progresses, the innovator should become more familiar with the school and should be able to customize the CBE application. The need for adequate communication and feedback mentioned earlier is essential to this fine tuning (Hirschbuhl, J., 1977).

The innovator must provide for continuity and maintenance. Personnel in the schools must feel comfortable about predicting what the innovator will do. Long-range plans, projections, and short-range target dates permit staff and line personnel to feel relatively secure when local plans are drawn.

The success of the CBE workshop, mentioned earlier, suggests the need for short periods of hands-on experience for all those involved. It also suggests the desirability of half-time internships that permit interested school personnel to work in and assist with the management of a CBE center. They would study the utilization of CBE by students, authors, and supervisors. Such internships would return personnel to the schools with the commitment and training required to maintain and develop instructional computing. These secondary factors would help integrate CBE into the institution's ongoing activities. They would help develop both a technical and organizational pattern that could support and maintain a CBE facility after the innovator leaves.

Summary

In the opening paragraph of this paper, it was stated that education is frozen in the technology of the past. It was suggested that the technological development and the social-cultural condition may be comparable to that of the old slate-board school. This condition was hypothesized as being at least partially the result of inadequately developed innovation plans.

One possible technique for improving the development of innovation plans is to assemble a set of case histories. Each case history would entail a careful analysis of the factors and procedures that influenced the successful or unsuccessful implementation of CBE in some educational institution. CBE innovators may profit, and education in general may profit, from the development of a collection of case studies that center on the implementation of educational computing. It would help satisfy the need for CBE implementation plans to be based upon what can be learned from prior efforts.

It appears that the times and events are such that the widespread implementation of CBE could be imminent. The question as to how long education will continue to sit on the brink of this breakthrough will be determined in part by the readiness of CBE innovators to act effectively within the education culture. It may well be that their effectiveness will be determined by the degree to which they are able to utilize the sociological and anthropological strategies that have been developed in the study of cultural change. Perhaps this is one of the keys to thawing the present technological freeze and unleashing education's "fourth revolution."

References

Allen, D. W. The Seven Deadly Myths of Education. Psychology Today, 1971, 4, 70-72.

Ashby, Eric. Adapting Universities to a Technological Society. San Francisco: Jossey-Bass Publishers, 1974.

Barnett, H. G. Innovation: The Basis for Cultural Change. New York: McGraw-Hill Book Co., 1953.

Barth, F. On the Study of Social Change. American Anthropologist, 1967, 69, 661-669.

Carnegie Commission. Chapter 11, The Fourth Revolution: Instructional Technology in Higher Education, 1972. A Digest of Reports of The Carnegie Commission on Higher Education. New York: McGraw-Hill Book Co., 1974.

Cunningham, W. G. Technology: A New Era in Education? Kappa Delta Pi Record, 1977, 14, 6-8.

DeCecco, J. P., & Richards, Arlene. Civil War in the High Schools. Psychology Today, Nov: 1975.

DuBois, C. The Public Health Worker as an Agent of Socio-Cultural Change. In W. G. Bennis, K. D. Benne & R. Chin (Eds.), The Planning of Change. New York: Holt, Rinehart & Winston, 1961.

Gallup, George H. Eighth Annual Gallup Poll of the Public's Attitudes Toward the Public Schools. Phi Delta Kappan, Oct. 1976.

Gibson, C. F., & Nolan, R. L. Managing the Four Stages of EDP Growth. Harvard Business Review, 1974, 52, 76-88.

Harnischfeger, A., & Wiley, D. E. Achievement Test Score Drop, So What? Educational Researcher, Mar., 1976.

Hirschbuhl, J. J. Occasional Paper: Blueprint for the Future of Computer Based Instruction. Computer Assisted Instruction Center, The University of Akron, 1977.

Hirschbuhl, Katherine. The Teacher and Technology- The Woodridge Study of CAI- A Three Year Study. In New Directions in Educational Computing, ADCIS Proceedings, 1977.

Jamison, D., Suppes, P., & Wells, S. The Effectiveness of Alternative Instructional Media: A Survey. Review of Educational Research, 1975, 44, 1-67.

Kroeber, A. L. Anthropology: Cultural Patterns and Processes. New York: Harcourt, Brace & World, 1963.

Niehoff, A. H. (Ed.) A Casebook of Social Change. Chicago: Aldine Publishing Co., 1966.

Nordskog, J. E. Social Change. New York: McGraw-Hill Book Co., 1960.

Sarason, S. B. The Culture of the School and the Problem of Change. Boston: Allyn & Bacon, 1971.

Schaller, L. E. The Change Agent. New York: Abindgon Press, 1972.

Sharp, L. R. Steel Axes for Stone-Age Australians. In E. H. Spicer (Ed.), Human Problems in Technological Change. New York: Russell Sage Foundation, 1952.

Stiles, L. J. & Robinson, B. Change in Education. In G. Zaltman (Ed.), Processes and Phenomena of Social Change. New York: John Wiley & Sons, 1973.

Tobias, S. Lack of Knowledge and Fear of Automation as Factors of Teacher's Attitudes Toward Programmed Instruction and Other Media. AV Communication Review, 1966, 14, 99-109.

Tope, D. E. Summary of Seminar on Change Processes in Public Schools. In Carlson, R. O., Change Processes in the Public Schools. Eugene, Ore: Center for the Advanced Study of Educational Administration, 1965.

THE USE OF COMPUTER-MANAGED INSTRUCTION TO CONTROL ON-SITE, SELF-INSTRUCTIONAL TRAINING IN A SMALL SYSTEMS CUSTOMER ENVIRONMENT

by

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The Association for the Development of
Computer-based Instructional Systems

SUMMARY

The cost of small computer systems is constantly decreasing, but the cost of training people to run these systems is constantly increasing. To make training cost-effective for its small systems customers, Digital Equipment Corporation has been providing self-instructional packages for several years that can be used by our customers on-site. To control the quality of this training, Digital is now incorporating Computer-Managed Instruction (CMI) into some of these packages. This CMI component uses a sequential probability algorithm that allows tests to vary in length depending upon the learner's skill level. This algorithm assures that the tests results are statistically reliable while keeping the length of the tests as short as possible.

SMALL SYSTEMS CMI
Jesse M. Heines

CUSTOMER TRAINING AT DIGITAL

Digital offered its first customer training courses in lecture format in the basement of its legendary "mill" in 1962. Today, Digital's Educational Services Department offers over 100 lecture and self-instructional customer courses that are available in six regional training centers in the United States and eleven centers in other parts of the globe.

In 1975, Digital began to market very small, turn-key systems. The costs of these small systems are so low that even with our regional training centers it is often not financially feasible for customers to send their employees to Digital for training.

To make cost-effective training available to these customers, we have developed a new form of training called "tutorial documentation". This documentation is designed specifically for teaching completely inexperienced users to operate their systems without having a Digital instructor present.

Traditional customer education at Digital continues to grow with the sales of our medium- and large-scale systems, and tutorial documentation has now added a new dimension to the training services that we can offer our small systems customers. We have found, however, that the use of tutorial documentation at customer sites presents two new problems of its own:

- it is difficult to control the use of these materials when they are used on customer sites as well as we can when they are used in Digital facilities, and
- it is difficult to get accurate feedback on the strengths and weaknesses of these materials from our customers.

Digital's Tutorial Documentation Group is addressing these problems by writing computer-managed instructional materials to run on some of these small systems. These CMI materials use the customers' computers themselves to control their learning and collect data that we can use to assess the effectiveness of the tutorial documentation.

The remainder of this paper describes an existing computer-managed instruction program that is coupled with the tutorial documentation for one of Digital's new small systems.

CMI IN A CUSTOMER ENVIRONMENT

Interaction with Tutorial Documentation

Digital's tutorial documentation is written in a modularized format. The modules are arranged in a hierarchy, based on the prerequisite relationships of their objectives. Each module contains a list of its objectives, text and diagrams to help learners master these objectives, and exercises to be performed both in the workbook and on-line. The test item banks for the module tests are all stored on-line.

Before learners begin work on the tutorial documentation, they take the pretest for the first module (see Figure 1). If they can demonstrate mastery on this test, they are branched to the pretest for the next module in the hierarchy. This loop continues until the learners come to a test on which they cannot demonstrate mastery. At this point, they are directed to study that module off-line, and return to the CMI system when they are ready for the posttest.

An important quality of the CMI approach is that it gets users on-line as soon as possible and therefore has a definite Hawthorne Effect. In the past, customers often just skipped the tests that were included in our training packages, because they felt -- erroneously -- that testing benefits only the teacher. It is difficult, if not impossible, to change this feeling, but we can capitalize on the Hawthorne Effect to get more of our customers to take the tests. The directions for booting the system and running the CMI registration program are provided in the tutorial documentation in cookbook terms, so that even the most inexperienced of our users can get the CMI system on the air.

General Characteristics

The CMI registration program allows users to register themselves interactively. It records their first and last names (making sure that each is unique), and their addresses. This program also allows users to view the status of their work on each of the modules in the course.

The CMI test administration program presents true/false and multiple choice items (with either four or five alternatives) to users on a CRT terminal. These tests are generated interactively in real time. The items are randomly selected from item banks that are categorized by module and objective. A typical item display is shown in Figure 2.

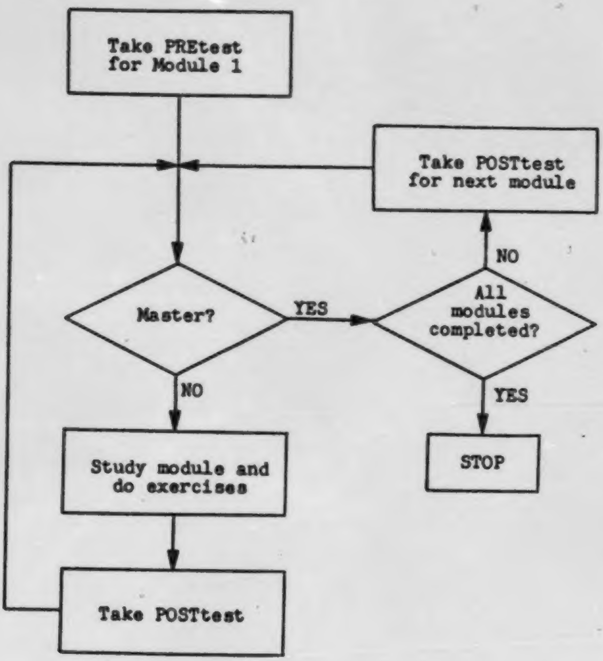
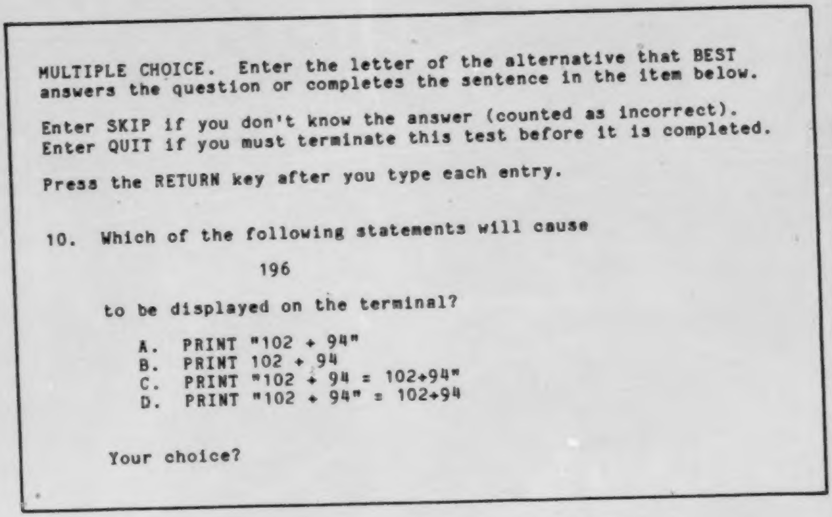

Take PREtest for Module 1
Take POSTtest for next module
NO
Master?
YES
All modules completed?
NO
YES
Study module and do exercises
STOP
Take POSTtest

Figure 1

INTERACTION BETWEEN ON-LINE CMI SYSTEM AND OFF-LINE TUTORIAL DOCUMENTATION



```
MULTIPLE CHOICE.  Enter the letter of the alternative that BEST
answers the question or completes the sentence in the item below.

Enter SKIP if you don't know the answer (counted as incorrect).
Enter QUIT if you must terminate this test before it is completed.

Press the RETURN key after you type each entry.


10.  Which of the following statements will cause

                  196

     to be displayed on the terminal?

        A.  PRINT "102 + 94"
        B.  PRINT 102 + 94
        C.  PRINT "102 + 94 = 102+94"
        D.  PRINT "102 + 94" = 102+94


     Your choice?
```

Figure 2

SAMPLE DISPLAY OF A MULTIPLE CHOICE ITEM
PRESENTED TO THE STUDENT

The system is highly human-engineered to make it as fool-proof as possible in a customer environment. For example, it provides the options "SKIP" and "QUIT" as shown in Figure 2, and it provides "error" messages in plain English: if the user enters "g" in response to a true/false item, the system will print, "Please enter only T, F, SKIP, or QUIT". It will then erase the user's previous response and make room for him or her to enter another one.

THE MASTERY DECISION MODEL

Sequential Testing

Even with a considerable Hawthorne Effect, customers still do not like to be tested. (There is always someone in every customer training course who will say, "I paid my money to be taught, not tested!") It is therefore important to keep the length of the module tests as short as possible. It is useless, however, to make these tests so short that their reliability approaches zero.

Since 1974, all courses developed by Digital's Educational Services Department have been developed using a criterion-referenced philosophy. This philosophy is especially applicable to industrial training, because we are interested in individual performance rather than a comparison between learners. We therefore required the CMI system to apply this philosophy as well. In 1975, this author reviewed the literature on criterion-referenced and computer-assisted testing, and the reader is referred to ERIC Document ED116633 for the complete text of that report.

The most highly developed criterion-referenced decision model that takes advantage of the capabilities of interactive computing is one developed by Richard Ferguson [1]. Ferguson's model is based on Wald's sequential probability test ratio [2]. This model allows two criterion scores to be defined, P0 and P1. Both of these scores are expressed in terms of percentages of correct responses. Learners whose scores are greater than P0 are classified as masters, and learners whose scores are less than P1 are classified as non-masters. Learners whose scores fall between P0 and P1 are presented with another item.

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[1] Ferguson, Richard L. Computer assistance for individualized measurement. Learning Resource and Development Center, University of Pittsburgh. March, 1971.

[2] Wald, Abraham. Sequential Anaylsis. John Wiley & Sons, Inc., New York, 1947.

This model also takes into account the probability with which the test developer is willing to allow Type I and Type II errors to occur [3]. For the purposes of the following discussion, let us define "A" as the probability with which we are willing to allow a Type I error to occur, and "B" as the probability with which we are willing to allow a Type II error to occur. The test developer can then assign values to P0, P1, A, and B to determine the learners' mastery state to any desired degree of accuracy.

Computations

After each test item is administered, the student's score, "S", is computed using the formula:

$$S = C \times \log(P1/P0) + W \times \log((1-P1)/(1-P0))$$

where "C" is the number of items answered correctly, and "W" is the number of items answered incorrectly.

If the student is a master,

$$S \leq \log(B/(1-A))$$

If the student is a non-master,

$$S \geq \log((1-B)/A)$$

If neither of these inequalities is true, i.e., if

$$\log(B/(1-A)) < S < \log((1-B)/A)$$

another test item is administered. The system continues in this manner until one of the first two inequalities is true or until 30 items have been administered. If no decision can be made after 30 items, the system classifies the student based on the differences between his or her score and the two criteria. The student is classified in the category whose criterion is closest to his or her computed score.

---

[3] A Type I error is a false positive error and occurs when a true non-master is classified as a master by the test. A Type II error is a false negative error and occurs when a true master is classified as a non-master.

IMPLEMENTATION

Test Parameters

As mentioned previously, our CMI system generates both pretests and posttests. For this reason, it is important to realize that the seriousness of making Type I and Type II errors is different on pretests and posttests. If we make a Type I error on a pretest, we will be telling a student who has not studied that module to skip instruction that he or she really needs. This same error on a posttest is not as serious, because the student will have already studied the module at least once. A Type II error is never as serious as a Type I error, because this situation simply asks a student to repeat instruction that he or she does not really need.

To take the relative importance of these errors into consideration, our CMI system uses the parameters shown in Table 1 for the sequential testing decision model.

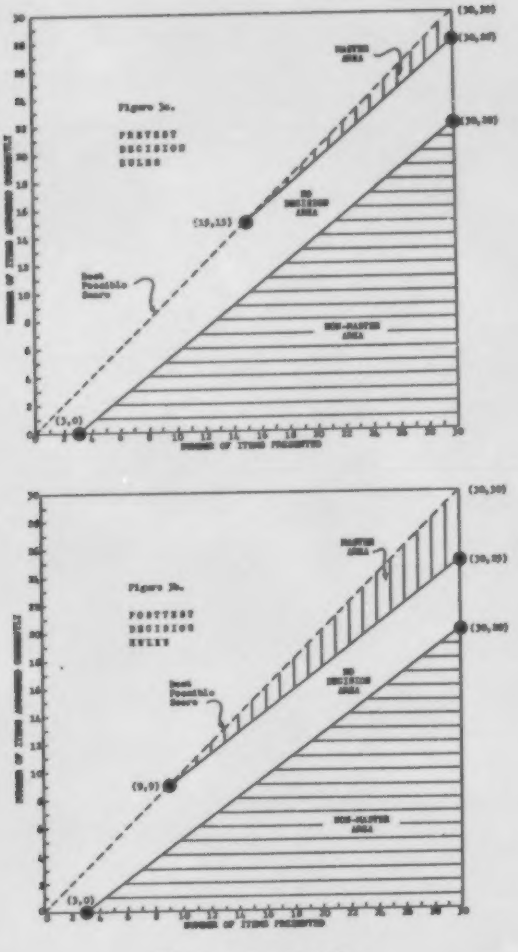
Table 1

SEQUENTIAL TESTING PARAMETERS FOR
PRETESTS AND POSTTESTS

Parameter	For PREtests	For POSTtests
Mastery Criterion ("P0")	0.90	0.85
Non-Mastery Criterion ("P1")	0.70	0.60
Allowable Probability of a Type I Error ("A")	0.025	0.050
Allowable Probability of a Type II Error ("B")	0.06	0.08

Notice that the allowable probability of a Type I error on a posttest is twice as high as that on a pretest. To see how these parameters affect the mastery decision model in terms of raw scores, refer to Figures 3a and 3b.

Figure 3a shows a graph of the pretest decision rules, while Figure 3b shows a graph of the posttest decision rules. Note the difference in the sizes of the two master areas and the specific points that are labelled. The point labelled "(3,0)" in both graphs indicates that the earliest that a non-master decision could be made on either test is



Figures 3a and 3b

GRAPHS OF THE PRETEST AND POSTTEST DECISION RULES after 3 items have been presented. If, at this time, the student has not answered any items correctly, he or she is classified as a non-master.

In Figure 3a, the point labelled "(15,15)" indicates that the earliest that a master decision could be made on a pretest is after 15 items have been presented and all 15 have been answered correctly. Contrast this point with the one labelled "(9,9)" in Figure 3b. The latter indicates that the earliest that a master decision could be made on a posttest is after 9 items have been presented and answered correctly. Therefore, the posttest mastery criterion is less stringent than the pretest mastery criterion. This is exactly what we wanted, because we have already shown that an erroneous master decision on a posttest is less serious than the corresponding error on a pretest [4].

Closing the Feedback Loop

The system on which these CMI programs are currently implemented is a diskette-based system. The complete CMI system will be supplied to users on a diskette even when they purchase the minimum configuration. After they complete all of the modules in the course, users will be instructed to mail their diskettes back to Digital in special business reply envelopes that will also be supplied. We will read their data, zero the log files if so requested, and return the diskettes. The data stored by the programs will allow us to do complete criterion-referenced item analysis on the users' responses and check the status of the users on each module. Users who complete the entire course will receive a diploma when their diskettes are returned.

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[4] The actual decision model implemented on our CMI system is slightly more complex than the one discussed here, because Wald's sequential probability test ratio was developed for events that occur with equal probabilities. Since the probability of getting a true/false item correct by guessing is different from that for a multiple choice item, our system computes a weighting factor to correct for the difference between our application of Wald's formulas and the probability model for which they were originally developed.

FUTURE ENHANCEMENTS

All of the programs that make up this CMI system are written in the BASIC language. This makes them highly transportable to almost all of Digital's operating systems, and we plan to use them for most of our tutorial documentation projects in the future. In addition, all of the CMI programs and data files for about 800 test items will fit on a single, dual-density diskette (approximately 250K PDP-11 words).

These characteristics make the CMI system applicable to internal and large systems training as well as small systems training, because it is small enough to fit on a diskette yet sophisticated enough to handle more and larger item banks if additional disk space is available.

We hope to begin putting appropriate parts of the actual instruction on-line on our small systems in the near future to complement the testing and course management functions that we have available today.

COMPUTER BASED EDUCATION FOR DEVELOPING EDUCATIONAL SYSTEMS

A Paper for a Topic Presentation at the
ADCIS Annual 1978 Conference
Dallas, Texas
March, 1978

by

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COMPUTER BASED EDUCATION FOR DEVELOPING EDUCATION SYSTEMS

The purpose of this paper is to present generalized conclusions on the use of computer-based education techniques in nations with developing educational systems. The conclusions are based on an 18 month study conducted in Brazil from 1975 to 1977 by the reporters. The study was the first of its kind in Latin America, and therefore the authors feel the results should be of interest to both nationals of developing nations as well as those interested in technical assistance to developing nations in the area of computer based education.

THE NEED FOR THE STUDY

The Brazilian Educational System is typical of many developing nations which has two outstanding features which make this study imperative:

1. Economic: the primary emphasis in the educational system is on economic development. The educational system must greatly improve to assume this responsibility.
2. Demographic: In a population of over 100,000,000 over 65% are 15 years or under and less than 2% of those entering school ever graduate from high school.

These two factors - the economic goal and the demographic situation add up to one over-riding fact. More people must receive more education. Rising aspirations and rising expectations for more people in an already under-educated culture produce inevitable pressures on the educational system. Coping with these factors is a large and formidable task which requires the employment of techniques already developed and the creation of new ones.

THE STUDY

The project to study the feasibility of using computer-based education techniques in the instructional system design in Brazil:

a. surveyed existing hardware and software facilities in Brazil paying particular attention to the capital of Brasilia where the study was located.

b. analyzed the existing instructional system of the Centro de Ensino Technico de Brasilia (CETEB), the specific locale of the study. CETEB is an autonomous educational organization, broad in scope and dedicated to educational innovations. All of its instruction (both direct, on campus and indirect, off campus) is designed to be individualized.

c. designed an integrated system for academic control and management by computer (Hereinafter called CAC/CMI).

- d. educated the software personnel in the specific programming required to implement the CAC/CMI.
- e. collaborated with the educators at CETEB in designing an instructional system to take advantage of the CAC/CMI system.

These activities are listed in the order of occurence, not in order of importance or of duration of time.

RESULTS

The results of the study are given in the same order as the study activities defined in the methodology above.

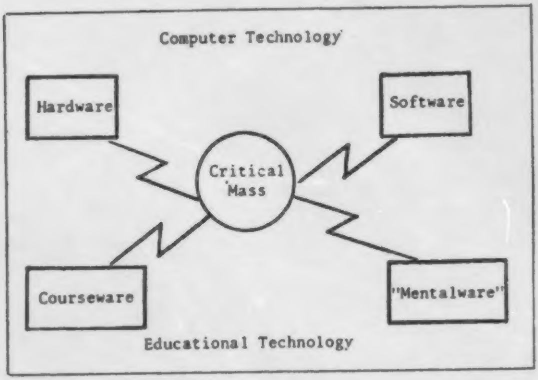
- a. Hardware and Software survey.
    - 1. Computer power is available in quantities sufficient for the needs of the CAC/CMI system. The machines are located in the business and government sectors as well as in the universities. None seem to be devoted exclusively to educational use. There is no need to recommend additional hardware.
    - 2. There is no software designed for instructional use although some existed for administrative control, particularly at the university levels.
- b. Instructional system analysis.
    - 1. There was but a superficial commitment to a systematic approach to instruction. Much work needed to be done to produce a truly integrated system which treats coherently the various inputs, the resulting objectives, the activities to meet the objectives and evaluation, both formative and summative, of the progress of the system and the learners.
    - 2. The individualization of the students' courses was limited to the student's own unique pace. Everything was uniform except the student's rate of speed in his studies.
- c. Design of CAC/CMI system.
    - 1. An integrated system for academic control and instructional management was designed with the following phases --
      --registration
      --instruction (amplified into a CMI system)
      --examination
      --termination
      --evaluation
- d. Instructional system design.
    - 1. Two position papers, on instructional system design and on computer based education, were written, in Portugese, as basic documents for the study.
    - 2. Course designs for CMI were tested experimentally. In addition to being designed to fit into the CAC/CMI system, these courses provided for the individualizing of student's pace, prior knowledge,

abilities and degree of autonomy in making his own educational decisions.

CONCLUSIONS

The principal conclusion is that the use of the CBE techniques in the instructional system is completely feasible. However, before this can take place various ingredients must be present in proper proportion {quantity, quality, and ratio} to form the "critical mass" necessary to produce the explosion of CBE. The following diagram demonstrates this concept in a graphic fashion.

CBE Ingredients Necessary for Critical Mass



Computer Based Education

RECOMMENDATIONS

To produce these ingredients in the proper proportion for this "critical mass," the following steps are recommended; it is further recommended that these be accomplished in the order presented.

1. A pre-disposition for systematic organization, which can be called "mentalware" must be fostered. This mentalware is a readiness to look at instruction as an integrated organic system. Creation of this readiness, this mentalware, may mean a new type of person in instruction--the instructional system designer. At the very least, creation of this mentalware means raising the level of expectations of the educators.

2. There should be an exploration of all the techniques in instruction made possible by CBE. A whole constellation of these techniques is available: individualized instruction, mastery learning, modularized organization, diagnosis and prescription of activities are some of these; to take full advantage of these requires an integrated system of instruction as well as computer management of the system.

3. The software development should include the four components of computer-based education: computers for academic control {CAC} computer managed instruction {CMI}, computer assisted instruction {CAI} and computer supported resources {CSR}. However, it is adviseable to develop these in the order given rather than simultaneously. Also it is recommended that there be concentration on the first two, CAC and CMI.

4. It is recommended that the same rather cautious development approach be taken with hardware. This is not to say that small mini-computers should be used instead of large main frame networks, but rather that small scale learning centers should be developed prior to national scale programs. In our case a mini-computer was recommended, but that was dependent upon the particular internal communications system of Brazil.

Strategies for Production and Dissemination of CAI

by

W. P. Olivier & G. F. Scott

In 1969 a cooperative Computer-Aided Instruction (CAI) project was begun which incorporated work started two years earlier. This earlier work at the OISE was typical of most CAI projects of that era, and unfortunately many projects today use the same techniques for producing courseware. The early notion was to provide an easy to learn but powerful author language and turn the creative teacher loose to produce high quality CAI. No matter how much technological support you provide a potential author, the task of producing good CAI and getting it accepted is monumental. CAI production could be compared to giving an amateur photographer a broadcast TV studio and asking him to single handedly produce a weekly series for next fall. Obviously the amateur would need help from professionals not only in directing, producing, camera work, lighting, etc. but also in advertising and distribution. Why do many CAI professionals expect regular teachers to be multi-disciplinary specialists without special training and support? Of course, many teachers can learn an author language or system; but how does this relate to high quality materials and their eventual wide spread use?

The Individualization Project at the Ontario Institute for Studies in Education (OISE) was organized on a cooperatve basis with a federal agency and several community colleges. There were several reasons for a cooperative approach. Financial considerations and their typical restraints certainly contributed to the joining of forces. The National Research Council of Canada (NRC) had a large computer, the OISE and colleges did not. The federal government in Canada has no educational mandate; education is a provincial matter. The NRC, a federal government research laboratory interested in CAI research across Canada, could not fund projects nor develop courseware themselves. The NRC could supply computer time and develop software and hardware. OISE had the skills to author courseware but suspected anything they produced in isolation would go unused. The colleges were new and full of both problems and eager faculty. Detailed accounts of these early developments and references to other related developments can be found in Olivier (1973) and Olivier, et. al. (1975). The main design goals were to produce needed courseware, move smoothly from R&D to a production mode of operation and to emphasize dissemination of courseware and systems. The project has grown from one terminal in a Toronto college to a coast-to-coast multi-processor network with distributed network control computers serving over 10,000 students in semester-length courses each year.

Project Organization

The project began with college teachers working, given the support of their administrations, about fifty percent of their time in defining goals and instructional materials. A needs analysis had been conducted earlier and pointed to a first year remedial mathematics course for business and technology students in community colleges. The teachers comprised a committee which had representation from around the province of Ontario. In producing an instructional innovation, the project organizers felt that a geographically representative set of trained authors would assist the dissemination effort. If a selling of CAI was to occur it was best done on a low key approach and from experienced teacher/users. Teachers could be skeptical about promotional activities by outsiders, but when another teacher had participated in the development a more convincing presentation could be made to other teachers inexperienced with CAI. The project was developing local change agents. At regional curriculum meetings a teacher working on the CAI project usually gave a presentation, not of a research project, but of the actual materials production which was occuring to solve their needs. Interest generated through peer contact was more likely to result in diffusion of CAI usage than if an expert offers workshops and demonstrations when no foundation had been provided by other teachers. The slow and steady growth by a group of people who believed in what was being accomplished gave the project a firm foundation. Perhaps the project was fortunate in not having large funding and had to compile skills and facilities among many agencies. The growth was controlled and subsequent steps built upon outcomes of earlier stages. Teachers also saw the benefits of working in committees when a one unit input (one teacher's efforts) in a committee of seven produced five units of output. This is not to say there were no frictions and arguments among the teachers. Differences were usually resolved quickly and criticisms were constructive.

The OISE staff performed several functions to support the teacher committees. Teachers were trained in 2-3 day workshops covering CAI techniques. Although the authoring language CAN (Olivier, 1977) was taught to the teachers, little direct use was made of this knowledge except to keep in mind some of the display, response and response judging restrictions of the system. Once the course structure and instructional strategies were decided upon, a format was created for specifying the tests and instructional materials, and these pages were used by OISE coders to produce the courseware. The teachers were thus free to design the student/computer interaction without the drudgery of coding and debugging. OISE coders could follow good and efficient coding practices such as modularity, item generation, algorithmic response judging, and keep documentation up-to-date. Most teachers have been uninterested in coding, indeed they have pursued an instructional career not programming. No matter how sophisticated the author language, a CAI project will exclude a lot of valuable and creative instruction if teachers are forced to use an author language. On the other hand, most automated systems to date have produced sterile interactions. The division of labor among specialists was extremely helpful.

An OISE research officer acted as a go-between for the teachers. This research officer (RO) had to be familiar with what the teachers wanted to accomplish as well as what was good CAI. The RO had to be familiar with the constraints of the CAI system to be able to direct the teachers into objectives they could reasonably accomplish. Acting as convener, secretary and committee chairman were other functions performed by the RO. The task of supervising the coders in the Instructional Programming Group (IPG) also fell to the RO. This individual was in effect the real course author with advice and materials provided on one hand by the teacher committee and on the other by the IPG. Advice and direction was also given by the OISE project directors. As might be expected, this individual was unusually capable, but not much harder to find than a good CAI author that has to use an author language and alone create a course. Formative evaluation design, data collection and analysis were other responsibilities of the RO.

Course development was functioning smoothly, but one day someone remarked that the OISE was in charge of a large number of teachers from different colleges and no formal body to oversee the production. To solve this reporting function and also to ensure continued development and cooperaton at higher levels wthin the colleges, an advisory group was formed. Usually deans or academic vice-presidents represented each college. This advisory group divided the responsibilities for course production among themselves. For example, when it was decided to produce courses in Mathematics of Finance and Technology Mathematics to follow the Prerequisite Mathematics course, different colleges committed teachers to each group. This advisory group is still functioning today. The OISE has withdrawn from full voting membership as part of the planned weaning of the project. During this next period we shall see if the structure and skills which have been developed among the colleges continues to work and more courses are cooperatively produced. Should the OISE presence be required, as exemplified by large scale local production of courseware without cooperation or coordination, we will again act as convener and organizer until such time as we can again withdraw.

Courseware Development Assumptions

A number of assumptions were made about the development process. These assumptions came out of the experience of the authors of this paper. Olivier had been a doctoral student and research project director of the CAI laboratory of the University of Texas and taught mathematics at the high school level. Scott had been a high school mathematics department head and been involved in educational data processing system design for packages such as school scheduling and financial systems. Both Scott and Olivier agreed on a number of assumption which had been seen as causes of failure of earlier efforts in development and dissemination.

Before CAI development could even begin teachers had to perceive that a problem area existed and that existing diagnosis and instructional techniques were not solving the problem. Too often, projects have defined a problem, produced a solution and delivered a package to teachers. More often than not the teachers response will be either: what problem, or they will reject the solution as not fitting their needs.

The product must also meet a broad range of needs, because of the development costs involved. When there is agreement in advance of production upon goals and objectives of a course, the acceptance and wide spread use is more likely. Compromises are inevitable, but courses produced to meet local needs are not accepted by other schools as easily as courses cooperatively developed. Since courseware must meet a broad range of needs, there must be some means of adapting the course to local needs. This adaptation mechanism must not be through program modification and the subsequent instability and unreliability of courseware, but by the ability to select portions of a course. The implementation of this feature can be through teacher control functions for selecting topics and perhaps their order within a CAI course, and/or if the teacher allows, by complete learner control functions within the course.

Any new technological innovations such as CAI, coming into a conservative establishment like schools must, at least initially, fit into the existing educational system and evolve. Any radical innovation, such as natural for CAI like self-pacing and continuous intake, does not merge with existing semestered systems. Even administrative details such as funding or legal statutes can be based on teacher-student contact hours. When a medium such as CAI can dramatically increase the efficiency and consequently reduce the student contact time, problems can accrue to the system. Impact analyses must be conducted so that the introduction of CAI, on more than just a casual basis, progresses smoothly.

School administrators are watching expenditures as never before, and any unnecessary expense is not tolerated. Extra and unnecessary frills in CAI should not be allowed and courseware must have proven effectiveness and low cost. Student motivational reasons have been an umbrella covering a lot of unnecessary digital cartoon graphics, pointing response detection, colour and audio which dramatically increase the cost of delivering CAI.

Effectiveness of courseware should be demonstrated. The most generalizable summative evaluation is one which has results from many experiments and not one large study. CAI is used differently, that is different degrees of integration into existing programs, and results from several implementations are a better indicator of likely success for a school than a single experiment where the use of the courseware might differ.

Threats to teacher's jobs, especially with declining school enrolments and in financially restrictive times, could cause outright rejection of CAI. A slow and steady growth using teacher peers to disseminate ongoing results helps to avoid the fear of job loss. Teachers can report the assistance which CAI has been and that no teachers have lost jobs because of CAI. On the other hand administrators can report how they have slowed the growth of the labour intensive teaching function by employing technology rather than hiring new staff to achieve lesser results. Teachers who have participated in the development of courseware can better relate to new teacher users.

Courses should be easy to use and there should be consistency of operation from one course to another. Many users of systems other than CAN have experienced the frustraion of learning to use a new technology, procedures and conventions when moving from course to course. Teachers using several courses with their students have experienced the differences and inconsistencies of reports from the system, if reports even exist. Learner control is, in essence, a structural way for students to ask questions and direct the operations of courseware. If the student has to learn a new vocabulary for each course then much valuable time is being wasted. This problem is compounded when a CAI course is a few minutes to a few hours in length rather than something comparable to a semester's work.

Courses should adapt, not only to local teaching goals, but also to individual student differences. Adaptive techniques such as hierarchical branching structures, variable-length testing, program modularity and generative coding with algorithmic response analysis such as discussed by Olivier and Lomberg (1974) make adaptive CAI easy to implement.

Other assumptions were also made by the project designers to respect to the more technical aspects: computer hardware, terminals, programming and data communications.

Technical Assumptions

A detailed account of the technical developments and references to other documents of this project can be found in Olivier (1976), Olivier and McClare (1977), Luts (1977a,1977b), and Dinniwell et. al. (1975). When the project began the only dedicated CAI system commercially available was the IBM 1500 Instructional System. Since data communications and costs were basic requirements, this system could not be considered. It was also decided to support earlier work in the CAN language and to allow for complex mathematical functions so other systems such as COURSEWRITER-3 would not have been acceptable. With a view toward the lowest possible operational and developmental costs and transportability, it was decided to code the developmental operating system in FORTRAN, a tactic being used for PLANIT. Suffice it to say that this system met all criteria except low operational cost. The OISE DECsystem-10 would run thirty CAN terminals under the FORTRAN coded CAN operating system and 300 terminals under the current machine language implementation of the CAN/CAI-CANNET operating system. A faster processor in the DECsystem-10 series will presently support nearly 600 simultaneous CAN terminals.

When the R&D phase of the Prerequisite Mathematics usage was nearing completion and the NRC DECsystem-10 computer would no longer be available, we asked the colleges to consider support of the courseware. The OISE offered to consult on the feasabliity of a CAN/CAI system for any mainframe which was selected. Seneca College in Toronto was the first to decide to upgrade their equipment for CAI and they purchased a Burroughs B6700. The OISE systems staff produced a CAN/CAI operating system for this equipment, and the system is being leased from the OISE to installations around North America. Today the Seneca system serves over 200 simultaneous CAN terminals with less than twenty per cent of the system resources. The system met the cost goals; Seneca charges less than one dollar (Canadian) per hour for CAN/CAI usage.

Algonquin College in Ottawa decided to upgrade the next year, and the OISE made the same offer. Algonquin purchased a DECsystem-10, and the OISE developed a CAN system based on the machine language. Algonquin still uses a version of this system. The following year the OISE purchased a DECsystem-10, and due to some unreliability and problems with the earlier system, recoded the DECsystem-10 CAN operating system. This latest OISE DECsystem-10 CAN operating system is now being leased by several places in North America.

It was important, at that time, to fit existing equipment and technology. By this fall or winter of 1979 it is reasonable to expect that dedicated CAN/CAI systems should be on the market further reducing the cost of delivering CAI.

No specialized terminals were required for the courseware developments. Other CAI systems have encountered too many difficulties and delays when there has been a reliance on specially designed terminals. Cost, reliability and delivery requirements kept us from depending upon special terminal designs. OISE staff acquired many one-of-a-kind terminals and even produced prototype terminal equipment but never recommended any to participating colleges. Most colleges purchased teletypes, Texas Instrument thermal printers, DECwriters, Hewlett-Packard 2640 CRTs or Volker Craig CRTs. Experience showed the first four types to be highly reliable.

Data communications was a continuous but necessary problem. With a decision of geographical spread of project participants for broad utility of courseware and ease of diffusion of products, data communications was necessary. Not only were communications necessary from terminal to host but among CAN host computers. For ease of course maintenance only one copy of a course under development exists. First this was the NRC system and later the OISE took over this role. Once a course is evaluated it is installed on all appropriate production systems. Communications processors initially served a concentration and data verification function. The CANNET processors were developed as a self maintaining, host-independent message switching system. Thus, a student on any CANNET processor is easily transferred to the appropriate CAN host system.

The CANNET communications system is similar to the older ARPAnet or packet switching. CANNET processors dramatically reduce communications costs where several terminals are located together. The CANNET processors also are equipped with loading, diagnostic and recovery routines for neighbour CANNET processors. The system is now automatic and does not require human intervention except for hardware maintenance and repair.

User convenience, reliability and low cost were overiding concerns in the development of the CAN/CAI-CANNET system. It is felt that we have met our goals as indicated by the growth in usage.

Growth Patterns

Growth of usage in Ontario has been steady. Were it not for saturation of computer resources at the Ontario service centres: Seneca and Algonquin colleges, many more student terminals would be in use. This school year a predicted plateau was reached. Seneca College can serve, because of other demands upon their machine, no more than 280 simultaneous CAN users. The OISE system, also because of other applications, fills at 40 simultaneous users running developmental courses. It is anticipated that 10,000 students will complete CAI courses this year, the same as last year. This represents usage at most of the Ontario colleges and other colleges across Canada. The figure for usage on CAN systems in the U.S.A. is unknown at this time.

The number of full semester-length college level courses has grown from the Prerequisite Mathematics course to include Technology Mathematics, Mathematics of Finance, Chemistry, Accounting and Electricity. Other courses comprising less that a semester's work exist. The largest production effort now is a complete mathematics program for grades 5 - 10. Increasingly, it is the availability of high quality courseware that convinces institutions to adopt CAI.

We have completed but not fully tested a COURSEWRITER-2 and -3 to CAN translator program. this program could allow an educational user access to all the COURSEWRITER and CAN courseware. The OISE would like to use the stat1 course developed for the IBM 1500 system at the University of Alberta. Other educational users could make use of this translator program and other translation features will soon be possible. a doctoral student at the OISE is producing a table driven translator to accept the definition of most course authoring languages and convert these to the CAN intermediate language (Voyce and Olivier, 1978).

A computer-based testing system has been produced by the OISE under contract to Seneca College and is available to Burroughs CAN/CAI system users. This operating system is written in ALGOL and we have not attempted to rewrite it in machine language as an extension to the DECsystem-10 CAN/CAI system. The testing system is a generalizable system of item classification and retrieval which accommodates different curriculum philosophies. System produced tests are given to groups and interactively to individuals. Items are coded by multiple selections from keyword categories. Each category selected is of equal weight and independent of all other categories. Weighting and dependence between categories is introduced when retrieving items. Users specify categories of interest, primary interest, excluded categories and the minimum number of category matches which must occur for item retrieval. The first item bank, implemented in 1976, contained items on health sciences. Other item banks are now operational.

The Individualization Project has become involved in practically every area of CAI activity in the last eight years. The key to these successful developments has been the cooperative nature and mutual respect all project participants had. This development approach seems to have implications not only for the introduction of CAI systems but also the introduction of other new technologies into educational systems. Early representative involvement of teachers supported and advised by "experts" was deemed critical for continued and wide spread use.

REFERENCES

Dinniwell, J. D., Luts, J., Mikichak, P., Naess, L., & Olivier, W. P. Developing a delivery system for computer-assisted instruction. Canadian Datasystems, June 1975, 54-57.

Luts, J. CAN-7 Implementation and Systems Operation Documentation Burroughs B6700 Implementation. Toronto: The Ontario Institute for Studies in Education, 1977a.

Luts, J. CANNET Site Operation Handbook. Toronto: The Ontario Institute for Studies in Education, 1977b.

Olivier, W. P. Computer-assisted mathematics instruction for community college students. International Journal of Man-Machine Studies, 1973, 5(3), 385-395.

Olivier, W. P. & Lomberg, Evannah S. Student Skill Deficiencies and Computer Assistance. In Konrad, A. G. (ed.) Clientele & Community. Willowdale, Ontario: Association of Canadian Community Colleges, 1974, 58-67.

Olivier, W. P., McLean, R. S., Brahan, J. W. & Payne, C. A Canadian Cooperative Computer-Aided Learning Project, In Lecarme, O. & Lewis R. (eds.) Computers in Education. Amsterdam: IFIP, North-Holland Publishing Company, 1975, 489-496.

Olivier, W. P. Cooperative development of a multi-processor CAL network. Proceedings of The 7th Ontario Universities Computing Conference, University of Waterloo, June 2-4, 1976.

Olivier, W. P. CAN-7 Author's Guide. Toronto: The Ontario Institute for Studies in Education, 1977a.

Olivier, W. P. & McClare, R. CAN-7 Implementation and System Operation Documentation DECsystem-10 Implementation. Toronto: The Ontario Institute for Studies in Education, 1977b.

Voyce, S. & Olivier, W. P. A solution to the problem of courseware sharing. Paper to be presented at the Canadian Computer Conference, Edmonton, Alberta, 1978.

Facing the Grim Realities in CBI: Copyright and Documentation

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ABSTRACT

This paper surveys two topics of importance in the implementation and dissemination of CBI: copyright and documentation. The discussion covers the purpose of copyright and documentation, special problems in copyrighting and documenting CBI materials, and different approaches or methods in the copyright and documentation of CBI. The importance of accepting copyright and documentation as integral components of CBI activity is emphasized.

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There are three major stages or phases that a CBI project progresses through. Stage I (infancy) involves the initial planning and organization of the project, acquiring hardware, developing or obtaining courseware, scheduling, and assigning responsibilities. Much of the effort in stage I is devoted to equipment problems and political squabbles. Stage II (adolesence) is mainly concerned with implementation details, the debugging, modification, and evaluation of courseware, achieving and maintaining reliability, and taking stock of the capabilities and limitations of the system. Stage III (maturity) is a production phase were courseware has achieved a "completed" or optimized status and the focus turns to the dissemination of the courseware and knowledge gained in the development of the project. In stage III, topics such as networks, copyright, documentation, and evaluation become prominent. Each of these three stages produces a different CBI environment and will involve different capabilities and talents on the part of the project members. Just as the infancy - adolescence - maturity metaphor suggests, there is a gradual transition from one stage to another and a project can revert back to previous stages at times.

This paper focuses on two topics which arise in Stage III: copyright and documentation. They are distinct issues, yet closely related to the general problem of dissemination of CBI materials. However, it is a mistake to think that these two topics are of no interest to CBI projects which are at stage I or II. As I hope will become evident in the following discussion, copyright and documentation problems become headaches because they weren't considered early enough in a CBI project.

Copyright and CBI

Copyright is essentially a means of protecting creative effort (and any financial benefits to be derived from this effort). It allows the public use of an intellectual product while still preserving the private ownership rights of the individual. While intellectual products are most typically thought of as literary works, copyright also covers dramatic and musical productions, paintings, photographs, films, sculptures, records, and any type of broadcasting. Copyright is established simply by affixing a copyright notice to any work when it first becomes publically used. It is not necessary to register a copyright with the Copyright Office to establish copyright protection, although this is a prudent move in the event of a subsequent infringement.

The question of whether copyright laws also apply to computer programs is a difficult one. It is generally accepted that the writing of a computer program constitutes a creative act and hence the program is an intellectual product worthy of copyright protection. However, a problem arises over the question of whether a computer merely reproduces the programs (as one reproduces a book, play, record, etc.) or whether the fact that the program transforms, selects, compiles, or controls a machine (i.e., its effects are intangible) makes a program different from all other intellectual products. While there is some consensus that the new U.S. Copyright Act is broad enough to protect computer programs without special provisions, it will remain unsettled until test cases establish a precedent. A comprehensive discussion of the issues involved is provided by Mooers (1975).

As if the application of copyright law to computer software wasn't problematic enough, the application to CBI materials poses further problems. Firstly, copyright laws usually have educational exceptions -- waivers of copyright infringement if the material is to be used in the course of instruction or private study. Secondly, CBI materials often involve a number of different media (e.g., audio, film, video, printed materials, etc.), each of which may have different copyright coverage. Thirdly, CBI courseware is often "consumed" in a non-tangible form, namely by viewing it on a cathode or plasma display screen. Only if copyright covers the actual execution of the program (as the performance of a play), will it provide protection. Finally, CBI courseware is dynamic and usually under a constant state of modification and revision. According to copyright law, every modification, no matter how minor, should be authorized by the copyright owner.

Given the problematic nature of copyrighting CBI materials, one might expect that little material has been copyrighted. In terms of sheer bulk, this is probably true. However, a number of successful CBI materials have been copyrighted, although different approaches have been followed. It will be worthwhile to consider briefly examples which illustrate different copyright arrangements.

In the traditional approach to copyright agreements, ownership and royalties belong to the author(s) of the material. This is exemplified by the arrangement made by W.F. Pillsbury (Knox College, Illinois) with South-Western Publishing Company for the marketing of his very successful computer-based accounting course. The copyright actually covered the student handbook and teaching guide while the program was provided at no cost. This agreement follows the usual approach of the publishing industry.

The copyright arrangement on the Huntington project materials was between NSF (who funded the project) and DEC. Royalties from the sale of the programs are paid to the State of New York and then funnelled back to the Huntington Project for further development work. In this arrangement, the ownership resides with the funding organization (NSF) and a computer company (DEC). The copyright arrangement of the REACT project materials which were developed by NREL (Northwest Regional Education Lab) under the support of the Office of Education is similar. However, with the REACT materials, the royalties are shared by NREL and the Office of Education.

Probably the most important CBI copyright agreement which presently exists is the one between the University of Illinois and CDC for PLATO. The agreement is quite comprehensive and establishes different classes of authorship and institutional participation which determines different percentages of royalty rates, release rights, and error correction responsibilities. For example, noncommissioned authors (students or employees of the university) have the sole right to designate whether courseware is ready for distribution, receive 75% of the gross royalties, and are responsible for the correction of errors. In the case of commissioned authors, however, the university reserves the right to decide whether the courseware is ready for release, the responsibility for error correction and the commissioned author recieves 40% of the gross royalties. Royalty rates for courseware are specified in terms of student contact hours according to instructional level and percentage of sales for ancillary (non-computer) materials. An important aspect of the PLATO agreement is that the ownership of all courseware is vested with the University of Illinois on behalf of authors. Thus the individual ownership rights are mediated by an educational institution.

These examples illustrate different approaches to the copyright of CBI materials. Two emerging technologies, microcomputers and videodiscs, are likely to have major effects on the copyright situation in CBI. Both of these technologies will allow the mass duplication of CBI materials while insuring that the original copy is difficult to produce and modify. This is essentially the same situation as books, records, films, etc. Microcomputers and videodiscs will also provide an inexpensive delivery medium operating under commercial incentives and constraints rather than an educational (non-profit) environment.

As CBI becomes a major component of mainstream education (as we all believe it will), copyright procedures must become an integral and automatic part of CBI. This means that courseware usage must be accurately logged and reported so that royalties can be computed. It also means that all CBI projects (whether at universities, school systems, or industry) must develop the appropriate administrative procedures for the payment of royalties. We also must be prepared for the grim realities of copyright -- infringements and legal actions.

Documentation in CBI

The documentation of computer software is a formal means of communicating information about the use and nature of programs. Without adequate documentation, information about the appropriate use and maintenance of programs tends to be haphazard. Ultimately this results in the inefficient operation of computer systems and economic loss. It is not surprising therefore, that considerable effort has been devoted to methods and procedures for software documentation in business and industry.

In the realm of computer-based education, interest in documentation could be described as anemic. This is rather unfortunate since documentation is absolutely critical to the field of CBI. Development of courseware is an expensive and time consuming activity. This effort can only be justified if the courseware can be shared by many students at different institutions. If such a transfer of material is to be accomplished successfully, documentation is essential. Documentation is also necessary to prevent the duplication of similar or identical courseware either between or within the same institutions. Just think of how many duplicate sets of arithmetic drill and practice programs or basically identical introductory statistics programs exist. Finally, documentation of courseware usage is needed in order to monitor student progress and also to evaluate the instructional effectiveness of courseware.

Most of the ideas which apply to the documentation of computer software in general also apply to the documentation of CBE courseware and materials. However, there are a number of important differences. One major difference is that rather than having a single category of user, there may be two or three types of users of a CBI program (student, instructor, proctor) each of whom will require different types of documentation. Another difference is that instructional software is much more concerned with monitoring user behavior and keeping detailed records than non-instructional software. Instructional programs often involve considerable use of graphic displays, special character sets, and mixed input modes as well as the syncronization with computer-controlled audio, film or video devices. Finally, instructional strategies and logics involved in the individualization of instruction require description which extends beyond that of the usual algorithms or methods embodied in non-instructional programs. In short, CBI programs pose many additional problems for the documentation of computer software.

The two major problems to be faced in the documentation of CBE software are (1) *what* is to be documented, and (2) *how* is this documentation to be produced. Consideration of the first question suggests the need for two major levels of documentation. Level I documentation is general and concise and designed chiefly to catalogue or identify CBI courseware. It's main purpose is to provide an interested user with enough information to decide whether a program is worth further investigation. Table 1 indicates the type of information which Level I documentation should contain. This type of documentation is exemplified by the *Index to Computer Based Instruction* which is compiled and distributed by the Instructional Media Laboratory at the University of Wisconsin-Milwaukee or the documentation of the Minnesota Educational Computer Consortium (see Koch, 1977). Level I documentation is brief and relatively inexpensive to produce and distribute. It is also independent of the size and complexity of the courseware.

Level II documentation, however, will depend upon the size, nature, and complexity of the materials. It is intended to provide the detailed information required by the individuals who actually work with the courseware. This includes five different types of users: instructors, proctors (i.e., teaching assistants), computer operators, programmers, and students. The distinction between the first four categories will depend upon the size and nature of the project. Thus, in a large CBI project such as PLATO, the instructor (author), proctor, computer operator and programmer will be different people. On the hand, in a school context, teachers are likely to design, write, and use the program themselves. In the case of a mini or microcomputer, one person may be all of these plus computer operator too. However, these five functions are distinct and necessary components whether they are fulfilled by separate or different individuals and hence documentation for each is required. Table 2 provides a set of suggestions about the information needed by each of the five types of users.

Having specified what needs to be documented, the problem remains of how to actually produce the documentation. There are three major approaches: manual documentation, self-documenting author systems, and post-hoc documentation produced from the code. Manual documentation involves developing administrative procedures or assigning task responsibilities to ensure that the documentation is produced. Self-documenting author systems require that a description be provided every time a variable is assigned, a loop initiated, a switch/counter used, etc. These descriptions become comments in the actual code. It has the added advantage that it allows the system to detect potential errors while the course is being developed, e.g., non-terminating loops, unassigned or dimensioned variables, missing branch locations and so on. The third approach, post-hoc documentation, involves developing programs which produce documentation from the code in terms of mapping out instructional strategies or logics, identifying variables, loops, counters/switches used, or providing cross-referencing.

Most CBI systems provide for the automatic documentation of student activity. Ideally this will include both records of individual student progress as well as a summary of group performance for particular instructional sequences or units. The former information is needed to evaluate the student; the latter to evaluate the instructional design. The need for the automatic documentation of system and courseware usage has already been mentioned in conjunction with copyright. This information also can also serve to document system reliability as well.

Where possible, the latter two documentation approaches are to be preferred over the first since automatic methods guarantee that a pre-specified standard of documentation is obtained. Furthermore, this will provide documentation of the program as it actually is, not as it was originally intended to be. Automatic documentation is intended to be helpful in overcoming the grim realities of documentation: sloppiness, laziness, and caprice.

Conclusion

It should be clear that copyright and documentation are important components in the development and implementation of CBI materials. Both copyright and documentation affect the dissemination, quality, and economics of CBI, and hence the eventual success of CBI as an educational methodology. Copyright and documentation must be accepted as integral aspects of a CBI project at the outset. The time to establish ownership and royalty arrangements, to develop system monitoring of usage, and to setup administrative channels for royalty payment is not after the courseware is developed but before it starts. Agreement on what should be documented and the procedures (manual or automatic. for producing this documentation must be established before programming begins so that documentation is available as soon as needed. Indeed, copyright and documentation may be grim realities but they are much less of a chore if faced earlier than later.

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REFERENCES

Koch, H.T. Documentation for instructional applications on a timeshare system. Proceedings of the 15th Annual AEDS Conference , Dallas, April 1977.
Mooers, C.N. Computer software and copyright. ACM Computing Surveys, March 1975.

Table 1.
Level I Documentation

1. subject matter of the course
2. description of content (very brief.
3. status of the course (development/operational.
4. author(s. of the course (person responsible for the definition of subject matter and instructional strategies.
5. exact address of author or person to contact for further information
6. availability and conditions for release of courseware
7. characteristics of intended student group (preferably mentioning appropriate pre-entry skills or grade levels.
8. types of instructional strategies / logics used
9. amount of time required to complete course (average and range.
10. support materials required (student handouts, manuals, textbooks, or special equipment.
11. support media (type of audio, film, video, graphics, etc., which are needed by the program/system.
12. the programming language
13. the system used (cpu and operating system.
14. the type of terminals used
15. applications (extent to which the course has been used for formal instruction.
16. published references (including any evaluation information.
17. date of this documentation

Table 2.

Level II Documentation

A. Instructor Documentation

1. major educational objectives of the course
2. pre-entry skills required for each objective
3. for each definable instructional unit within the program, a description of:
   i) subject matter content
   ii) instructional strategies used
   iii) media support required (audio, workbooks, etc)
   iv) average time for completion
4. availability and nature of performance records used to monitor student progress
5. complete screen by screen display of programs
6. availability and source of evaluation results/studies
7. degree of instructor intervention/assistance required
8. disclaimers and restrictions on use and modification of program

B. Proctor Documentation

1. need for and meaning of any student registration procedures and passwords
2. a description, perhaps by flowchart, showing the entry points in the course, the sequence of instructional units, and the variations of sequence possible due to individualization or branching
3. the need for and location of proctor intervention, including a list of messages and appropriate action to be taken
4. a complete list of all questions asked in the program and correct and incorrect answers
5. a description of procedures for allowing a student to bypass or review a unit in the course
6. the location within the course of all examinations
7. procedures for handling cheating or system failures during exams

C. Operator Documentation

1. the nature and location of the course code (source, object, etc.)
2. the operating details of the hardware involved (e.g): cpu, discs, tapes, terminals, printers)
3. the details of the operating system and all system software (including startup, backup, and emergency procedures)
4. parameters affecting the computer resources needed for each program (memory, graphics, character fonts, etc.)
5. recovery procedures for system failures (hardware or software)

D. Programmer Documentation

1. availability of source code listings for each course
2. the names and locations of all functions, macros, variables, labels, etc), within the course
3. the particular programming strategies/logic used to produce certain instructional displays or effects
4. a complete listing of all error messages which might occur, their meaning and corrective action

E. Student Documentation

1. course outline giving organization of course
2. description of how to use system and terminals
3. description of any scheduling arrangements (when the system is available for that course.)
4. how to communicate to the author/instructor via the system (if possible.)
5. how to use any special system features (e.g., calculation mode, learner control keys, etc).

Project Report: The Navy's CMI System (You've Come A Long Way, Baby!)

Nick Van Matre
Navy Personnel Research and Development Center

The Navy's Computer Managed Instruction System was initially developed by the Navy Personnel Research and Development Center in Memphis, Tennessee, in 1968. The original instructional materials were designed to provide individualized instruction in an Aviation Mechanical Fundamentals course, a then 6-week course, to about 500 students per week. Individualization of the materials and automation of the instructional management resulted in the average course length dropping to about 2 weeks, for a phenomenal decrease in training time. A few additional courses were added to the small system, at that time still operating only in Memphis.

A formal decision to go operational with CMI was reached in 1971 on the basis of cost-effectiveness study which estimated CMI being cost beneficial after the number of students on the system was larger than 1,300 daily. Acquisition of the operational computer system occurred through competitive federal contracting procedures with Honeywell, Inc., landing the contract. Notably, the contract specifications require the contractor to maintain system reliability at the 95% level for the projected life of the system.

The resulting operational CMI system which now manages instruction not only at Memphis, Tennessee, but also at Orlando, Florida, Great Lakes, Illinois, and San Diego, California, and provides daily instructional management for over 6,000 students registered in 9 courses under the command of the Chief of Naval Technical Training. The system, when fully implemented, will manage the instructional progress of about 13-15,000 students, in 24 courses, in five locations. This amounts to 28% of the entire Navy technical training student population. It is noteworthy to describe what ~~even now~~ is the world's largest operational CMI system.

In the Navy CMI system, instruction is provided on an individualized basis via written and mediated instructional materials. The courses are divided into modules of instruction, each module comprised of 2—7 lessons. At the end of each lesson, a student takes a self-test, checking his own answers. When the student has completed all the lessons, he takes a module test which is comprised of up to 50 multiple-choice items. Responses are entered on machine-scorable answer sheets which are submitted to an optical scanner. The computer system scores the tests and makes subsequent study and test assignments. Since the Navy requires all personnel to acquire all the requisite skills and knowledges, achievement is based on a Keller-like model requiring 100% mastery of all objectives. The computer makes the necessary remedial assignments. Data analysis, performed on the computer system, can include not only determinations of individual student achievement, but also summary evaluations for purposes of course evaluation, test item analysis, and even for facilitating the daily instructional progress of students.

Although the Navy CMI system has come a long way, it is going even farther. Along with its planned expansion in size, additional functions are being explored to add an automated performance testing capability using minicomputers for initial data processing before feeding to the centralized computer facility. Other efforts are underway to develop automated procedures for assessing student and instructor attitudes. It is even being considered to add various simulation capabilities onto the existing system, or as a second-generation system, to make it truly an interactive computer-based instructional system. One major point is clear, the Navy continues to strive toward a training system which is both instructionally and monetarily effective, and computer-based instruction (CMI) is leading the way.

COMPUTER-BASED EDUCATION FOR PROFESSIONALS IN THE FINANCIAL SERVICES

by

Robert C. Fratini, Instructional Design Specialist
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This project report is a summary of The American College's research into the feasibility and value of computer-based education for the College's nationwide student body. Founded in 1927, the College was one of the nation's first nontraditional institutions of higher learning, and today continues to operate along the lines of an "open university". The College is divided into three schools, the largest of these being the Solomon S. Huebner School of CLU Studies. The Huebner School offers the 10-course curriculum leading to the CLU (Chartered Life Underwriter) diploma and designation to life insurance professionals, who receive credit for their study by passing the College's semi-annual national examination for each course. It is in three of the courses of this school that the College has conducted its efforts in computer-based education.

Although the College has over 60,000 active students, only approximately 400 students actually attend classes on the College's Bryn Mawr campus. About half of the students prepare for the College's national examinations by attending local classes throughout the United States. The other half of the students prepare for the examinations independently, or in small study groups, using learning materials developed and distributed by the College. In addition, the College's students are just as disparate in terms of their educational backgrounds as they are geographically distributed, ranging in education from high school graduates through Ph.D.'s, and in age from 18 to 80.

Computer-based education is currently one of the methods the College is investigating in its effort to better serve this widely scattered student body. Beginning in February, 1976, with a course-development grant from Control Data Education Company, the College designed portions of three of the ten CLU courses for computer-based study by its students through means of the Control Data PLATO network.

There are a number of reasons why computer-based education is well-suited to serving the needs of the College's student body. First, computer-based courses can be designed so that they complement both classroom study and independent study, without replacing either of these traditional modes of learning. Second, students can make use of computer-based instructional materials at any time during any day, at the student's convenience, for varying lengths of time, knowing that each new session will begin at exactly the spot where the student last studied. For students such as the College's, who work full-time and maintain extremely heavy professional schedules in addition to their studies, this feature is particularly advantageous.

Third, adult learners often have different learning styles from those of children, and computer-based education seems to be well-suited to accomodate their needs. Adults generally prefer to choose their own paths through instruction, and the computer allows them to do this while providing record-keeping as to which subject-matter areas remain to be mastered. In addition, adults are often much more embarrassed to be caught making an error in the process of learning new material than are children, and the privacy of the learning process (just the student and the computer, who never jeers at a mistake) is another factor in the computer's appeal to adult learners, although several of the College's students have worked successfully in pairs at the same computer terminal.

And fourth, computer-based materials are ideal for reviewing previously learned material just prior to an examination. Since the College's students may study material in September for a January national exam, the fact that computer-based learning materials can be designed to allow unlimited review as well as allowing students to skip items previously answered correctly is still another way in which the computer can rise to meet the needs of the adult learner.

Although each of the three computer-based courses embodies a different design and philosophy, all three were developed with the intention of making use of the computer's unique abilities to enhance the learning process. Since a number of perfectly adequate learning materials already existed in print form, there seemed no need to simply re-do them on a different medium. Thus, we chose to take advantage of such existing materials wherever possible, building upon them and incorporating them into the computer-based course. In addition to print and text materials, The American College's Cassette/Review audio-cassette/workbook module for the particular CLU course was also cross-referenced to each computer-based course.

The computer-based materials in Economics cover the areas of Microeconomics and International Trade, which make up the last third of the CLU course in Economics. The PLATO materials consist of pre-tests, references to an off-line workbook, supplemental on-line instruction, broad simulation-type review activities, and post-tests. The materials were designed so that the student would receive as much practice as possible in working with the concepts, to the point where the student must actually draw graphs on the display by means of the PLATO terminal's graphic capabilities. The students may choose one of three modes by which he can work through the materials: Introductory Mode (which assumes no entry knowledge of the subject-matter), Review Mode (in which the emphasis is on identifying the areas in which the student still needs further study), and Freedom of Choice (in which the student simply receives an index and is free to use any of the materials in any of the lessons). Students receive the same materials in each of the three modes; the difference is in the order in which they are presented.

The computer-based course in Analytic Accounting covers the first half of the CLU course in Accounting and Finance and is designed for the individual who must interpret financial statements rather than the accountant or bookkeeper who must prepare them. Unlike the computer-based Economics materials, the Accounting materials are designed as review-type problem situations requiring the student to apply his knowledge of the subject-matter; the student should have at least read the appropriate text assignments before sitting down at the computer. The PLATO materials offer the student two types of "HELP" in these problem situations, a choice of specific page reference in the text, or a brief explanation or example. Other features of these lessons include randomized numbers in each of the problems (so that when a student repeats a problem for review he learns a process rather than the correct answer for one particular problem), an on-line, touch-activated calculator with three displayed memories, and the ability to skip a question already answered correctly at some previous time. At the end of each problem situation the student is given his score for the lesson, told whether it meets the level of achievement chosen by the College's subject-matter experts as "satisfactory", and given the choice (but is NEVER forced) to repeat the problem.

The College's most recently developed computer-based course is The Mathematics of Life Insurance, covering the entire mathematics section of the CLU course in Life Insurance Law and Mathematics. Each of eleven subject-matter topics has its own index, featuring a text reference, a quick reference to important concepts and calculations, a 10-item quiz (in which a score of 90% is required for mastery), instruction and practice (which leads the student through the subject matter), and drill (which provides the student with a large number of randomly-chosen problem situations). After indicating his mastery of each of the subject-matter topics, the student is given the opportunity to take a 25-item examination with the same types of test items as the national CLU examination, which features feedback to the student at both the halfway point and the end, both on the basis of performance and the student's ability to finish the entire exam within the given time constraints. Since many of the students find it difficult to properly pace themselves in an examination situation, this feature is particularly helpful.

In its two years of work in computer-based education, The American College has discovered much useful information concerning the construction of computer-based courses for adult students. One of the most basic points is the extreme usefulness of actually observing students pilot-testing computer-based materials; by having a PLATO terminal for student use in our offices, we discovered that a student's muttered threat to put his fist through the display is a much more vivid indicator of a design problem than a simple "unrecognized wrong response" on a printout. One should not infer student hostility from the above example, however; all of our on-campus pilot PLATO students have been uniformly positive towards the experience, several citing it as the single most valuable aid to passing the national exam that they used.

Adult learners seem to have other interesting attitudes towards computer-based education. While they marvel at the capabilities of the computer, many seem afraid when working at the terminal, as if pushing the wrong key on the terminal will cause the entire system to crash. A short introduction, even one light enough for children, will go a long way in helping students to overcome their initial trepidation, and as a result an introduction to PLATO and an introduction to the particular course are the first choices offered to the students in each of the courses. Many of our students resent being led in their learning, even by a computer that presumably knows more than they do; as a result, we have tried to allow the students to make their own learning choices with the help of frequent checks and suggestions, and have discovered that the majority of students work through the materials in just the sequence one would have wanted.

Perhaps the greatest barrier in our students' use of computer-based lessons has been their poor typing and spelling abilities. Since the primary means of communicating with almost any computer is a keyset, one can see what a problem this can create for interactive learning programs. Removing PLATO's system mark-up and automatic "no"-judgment of misspelled words has gone a long way towards easing our students' task, and each successive program that we've developed has sought to lessen the typing required while still presenting

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learning concepts in the best possible format to take advantage of the computer medium.

Both The American College and its students have come a long way in computer-based education in a very short time, with both groups seeing the experience as a very positive one. Just as the College's adult learners require an open environment with the freedom to choose their own individual styles for study, the College itself sees computer-based education as a wide-open field in which an entire spectrum of innovative instructional designs can now be made available to its nationwide student body.

PROJECT REPORT: A Computerized Bibliographic Index of Musical Scores by Black American Composers Prior to 1910

The Center for Research in Black American Music at Southern Illinois University Carbondale is developing a data base containing bibliographic information, location, and descriptive comment on all known musical scores written by black American composers before 1910. The goal of the project is to provide interested scholars with an efficient computer indexing system for discovering what musical scores by black Americans exist from prior to 1910, and where they may be found.

The Remote Information Query System (RIQS), developed at the Vogelback Computing Center, Northwestern University, was adopted for the software. It is available to Southern Illinois University through the Mid-Illinois Computer Cooperative, via interactive terminals to a CDC Cyber 72 computer. The RIQS system was designed to allow the non-programmer to define a suitable record structure, create a file, and retrieve and analyze the data in batch, on-line, graphical, and statistical modes. It is sufficiently generalized to manage either text or numeric data. Record structures, search procedures, and report generation are controlled by the user, and can be tailored to individual needs. Processing is interactive, providing speed, convenience, and flexibility.

When fully implemented, the index files will contain an estimated five thousand records, with separate items for composer, title, edition, publisher, place, date, repository, performing medium, comments, and additional items for which a need becomes evident. Records may be searched by any item, keyword, or combination, and reports can be generated on any standard output device, in any format desired. Search commands, as well as report contents and format, are specified by the user, in relatively simple, user-oriented language. Information from the index will be made available to scholars as a service of the Center. An accumulated data base sufficient for limited use should be available by fall, 1978.

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Hardware: CDC Cyber 72 system

Software: Remote Information Query System (RIQS)

COMPARING TRADITIONAL AND MODERN WAYS OF TEACHING ENGINEERING STUDENTS MATHEMATICS AND PHYSICS

Günther Kurz, Rainer Eggensperger, Gunnar Voss

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1. EDUCATION AT FACHHOCHSCHULEN

CAT (Computer Assisted Training) is a research project [*)] at the Fachhochschule für Technik in Esslingen, W-Germany. Similar to a college of engineering the Fachhochschule für Technik offers a practice-oriented higher education in technical subjects. The study leads to a degree in engineering (graduated engineer). It takes four years that is eight semesters including two spent in industry. It can be divided into two parts: the foundation studies and the main studies.

The aims of the project are to develop and evaluate new means and methods of instruction giving the student a more active part. As the name of the project implies special emphasis is given to the computer as an aid of instruction, mainly for drill and practice.

Up to now the project has been concerned with students in the foundation studies in the department of mechanical engineering. The chosen subjects have been mathematics, physics and technical thermodynamics. For the main studies the program 'Finite Elements' has been developed as an aid in mechanical design.

During his training the student spends a weekly average of 28 hours at lessons. During the foundation studies 90 % of this time is spent on lectures and only 10 % on practical work and exercises.

2. CAT's INTEGRATED MEDIA MODEL

It is our idea to reduce the time used for lectures to about one half and use the other half for more active ways of learning.

The media model comprises:

- reduced lecture
- course booklet
- small group work with tutors
- selection of exercises and model solutions to the problems
- computer programs
- tests for self-evaluation

[*)] The project has been supported by the Stiftung Volkswagenwerk, the Bundesministerium für Forschung und Technologie, the Bundesministerium für Bildung und Wissenschaft and the Kultusministerium Baden-Württemberg.

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The lecture gives an overall view of the subject and is meant as a guideline for the students. The illustrated course booklet covers the topics more extensively. It is printed in such a way that the student can add notes and it contains a glossary of important terms. Exercises are done in small groups and by computer assignments. These aids are organized in such a way that they can also be used without the computer programs. This is important as still most Fachhochschulen lack the necessary hardware facilities. The tests have a twofold purpose: in the first place the student can check his understanding of the material and secondly the efficiency of different teaching methods can be assessed.

Up to now the components of this media model have been developed for the following instructional units (each encompassing about 20 teaching hours):

Mathematics	- vector calculus - matrix calculus - integral calculus I and II - complex numbers
Physics	- heat and thermodynamics - electricity - oscillations
Technical Thermodynamics	- ideal gases

3. COMPUTING FACILITIES AND CAI PROGRAMS

For three years we were connected to a distant large scale computer (SIEMENS 4004) using two and for a short period up to six teletype terminals. In 1977 we could only use two IBM 5100 minicomputers. In 1978 we will have a PDP 11/34 at our disposal together with six display terminals (five HP 2641 A and one Tektronix 4013). First using PLANIT we switched to APL two years ago.

Up to now some 20 CAI programs have been developed in the following areas:

- vector calculus
- matrix calculus
- integral calculus
- oscillations
- ideal gases

The CAI programs in the instructional unit 'Vector Calculus' deal with the basic rules of vector algebra, vector products and geometrical applications of vectors.

The programs of the unit 'Matrix Calculus' cover the basic properties of determinants, evaluation strategies for determinants, matrix multiplication and inversion.

The programs of 'Integral Calculus' deal with the properties and applications of definite integrals, the integration of elementary functions and some special methods of integration.

The programs of 'Oscillations' deal with the basic notations and relationships, simple and damped harmonic motion, forced oscillations and resonance.

The programs in 'Ideal Gases' deal with the properties of ideal gases and thermodynamic cycles.

4. EVALUATION OF TEACHING METHODS

In order to compare the efficiency of different methods of instruction the project CAT has constructed achievement tests for each instructional unit. For some units there are also course-entrance tests measuring the preinstructional knowledge of the students at the beginning of an instructional unit. These tests all use the multiple-choice format. In addition there are questionnaires to find out the attitude of the students towards the different teaching methods used.

One condition of the federal grant was to test the developed printed aids of instruction at many Fachhochschulen in the Federal Republic. To achieve this we first tried to get the comments of as many students, tutors and faculty members as possible for a formative evaluation of the material. The second objective was to get colleagues at other Fachhochschulen interested in our approach of teaching. This we judge to be a very essential objective as it compensates for the high initial costs, and fortunately we were successful in gaining the cooperation of colleagues at 31 Fachhochschulen out of some 60 in the Federal Republic.

Instructional Unit	Complex Numbers		Integral Calculus I		Oscillations		Ideal Gases	
Teaching Method	L	M	L	M	L	M	L	M
Number of Students	76	76	72	69	54	49	18	13
Preinstructional Test Score	.57	.58	.39	.39	.30	.36	.45	.53
Achievement Test Score	.49	.54	.29	.28	.27	.31	.21	.24

Table 1 Mean test scores from 14 experiments carried out in divided classes. 'L' stands for lecture and 'M' stands for media model.

The preinstructional test score is the fraction of the items solved correctly. The achievement test score is the fraction of the difference between posttest and pretest points divided by the difference between maximum number of possible points and pretest points.

In a first phase we compared traditional lecturing with our multi-media model in some 60 classes half of them using the CAT material. The achievement was measured under both conditions. Later on both teaching methods were used by the same lecturer his class being divided into two equivalent parts. 14 experiments of this kind were carried out. The results are summarized in Table 1. Up to now only four experiments comparing CAI with lecturing could be performed. The reason for this was the restricted number of terminals available.

5. SUMMARY OF THE MAIN RESULTS AND CONCLUSIONS

- The teaching by the CAT media model leads to a higher or at least the same level of achievement as traditional lecturing.
- The printed material is easily transferable but there are difficulties with the computer programs with this respect.
- Colleagues at other Fachhochschulen are interested to use the CAT material.
- The students show a positive attitude towards this new approach of teaching.
- There is a high correlation between achievement and preinstructional knowledge.
- The low level of preinstructional knowledge indicates a need to organize additional courses for the students to compensate for their deficiencies.
- It might be expected that future experiments will show more clearly the potential of the CAT media model provided the students have a sufficient preinstructional knowledge.

We thank all persons who have been involved in this investigations mainly the members of the Projektgruppe CAT and all institutions supporting us.

Progress Report

New Developments in the CASPER CMI System

H. McDaniel
C. Guerra
J. Kaufman

The CASPER system provides a computer aided curriculum and course management package as well as a computer aided testing system (1,2). In development since 1972, the system can provide management and testing for a curriculum of 256 courses and 1000 students. The system can store unit, examination, and course completion times and scores for all courses in addition to providing testing for any number of them. The CASPER system was created for the University of Illinois College of Pharmacy on the University of Illinois PLATO system. This site uses 12 PLATO IV terminals, a Termi-Net 300 KSR printer, a Microdata 120 cps dot matrix printer with graphics capability, and a programmable interface (3) for the Microdata printer.

Since the last CASPER ADCIS presentation (4), the system's user's options have been reorganized in a more logical and simplified order. Additional HELP pages, improved ways to get from one student record to another, more convenient connections from one option to another and improved layouts of displays are amoung the improvements made. A new router has been constructed to allow routing to lessons in addition to CASPER record keeping and testing. The router is similar to "mrouter" in use and editing, but allows choices within hierachically structured categories rather than linear lists as in "mrouter". However, the router does not allow for specification of sequences. Usage tables are included which can determine lesson access on the basis of signon, terminal and time classifications.

The first components of the test evaluator have been completed, including for each test, item analysis, average scores, percentages and standard deviations. Multiple response questions can now be administered by CASPER. Comments can be entered for students to see whenever they encounter a switch in categories within their tests.

A resident program for the programmable printer interface is due for completion by January, 1978. This progam can process the incoming PLATO bit patterns and translate them to ASCII, when necessary. The interface also automatically adjusts the platen to handle superscripts and subscripts. Two characters are processed for each "external" terminal output, yielding a theoretical print speed of just under 120 cps. The programmable interface allows any printer to interface to CASPER software using PLATO IV, V or IST terminals. Of course, the proper connection (RS-232, serial or parallel) must be specified for the terminal.

Two PLATO V terminals are due to replace two PLATO IV terminals in the early part of 1978. This will enable development of ppt programs such as that for the programmable printer interface. These programs will be compatible with any PLATO V terminal, or any IST terminal which includes the optional 4K words of extra memory.

(1)McDaniel, H., Guerra, C., Kaufman, J., Bonetti, W., Galcher, W. and Lamprinos, P., "CASPER-The Record Keeping Component, "Proceedings/1976 Summer Conference/ Association for the Development of Computer-Based Instructional Systems, Minneapolis, Minnesota, p. 195, 1976.

(2)Guerra, C., McDaniel, H., Kaufman, J., and Fuller, D., Lamprinos, P., Long, J., and Nelson, C., "CASPER: An Interactive Approach to Computer-Managed Testing", "Proceedings/1977 Winter Conference/ Association for the Development of Computer-Based Instructional Systems, Wilmington, Delaware, p. 55, 1977.

(3)Available from F. Ebeling, Department of Electrical Engineering, University of Arizona, Tucson, Arizona, 85721.

(4)Guerra, C., loc cit.

CBES -- An Efficient Implementation
# of the Coursewriter Language

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During the past eight years The Ohio State University has developed an extensive computer based education system built around the IBM Coursewriter III program product. Numerous extensions have been added to the Coursewriter III language to provide capabilities needed to implement sophisticated instructional strategies. Currently there are fifty operational courses being used by both undergraduate and graduate level university students. These courses may be accessed by a maximum of eighty simultaneous users with as many as 70,000 student interactions provided by the system in a sixteen hour operating day.

The CBE activity takes place on an IBM 370 model 158 computer system. In addition to CBE, this computer provides concurrent processing for three other on-line systems and a variety of batch applications required for routine university operation.

During the Spring Quarter of 1976 CBE activity was consuming over 70% of the CPU at peak usage times with resultant degradation of service to both CBE and non-CBE users alike. The average CBE student interaction was calculated to take .4 of a second CPU time. This high CPU usage, coupled with a disk accession rate of over two million per day, led to a growing concern among those responsible for maintaining computer services. As computer operations essential to university operation were increasingly degraded, it became apparent that action of an immediate and drastic nature would be required.

Initial stop-gap measures included a curtailment of CBE development and the diverting of student usage toward non-peak hours. As a result of these measures, a state of equilibrium was achieved; a poor but acceptable system response time for all university on-line systems could be maintained during the entire working day.

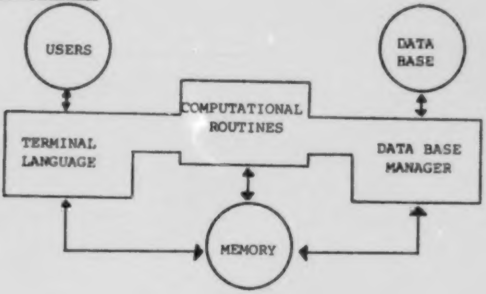
A general CBE retrenchment was considered, whereby some of the educationally less valuable courses would be removed from the system. This approach was abandoned in the realization that these courses were being only lightly used and that their removal would have little effect upon the problem. The acquisition of a faster computer was also discussed, but lack of available funding forced this approach to be abandoned also.

With the opinion that .4 of a second CPU per student interaction -- roughly 300,000 machine instructions -- was excessive, a study was begun of IBM's Coursewriter III program product to determine in what areas it could be made more efficient. A few week's study of the program, however, indicated that to achieve the efficiency gains necessary for the continued survival and growth of The Ohio State University CBE program, nothing short of a complete redesign and recoding of the system program would be required. Such action, it was hoped, would result in a significant reduction in computer resources used by the CBE system. In July of 1976 work was begun on the Computer Based Education System (CBES).

CBES Design Goals

1. lower CPU usage per student interaction
2. fewer disk accessions per student interaction
3. all existing course materials to operate without alteration
4. system modifications to be transparent at the student level
5. standard Coursewriter III authoring capabilities to be maintained
6. provision for enhancements to be made where practical

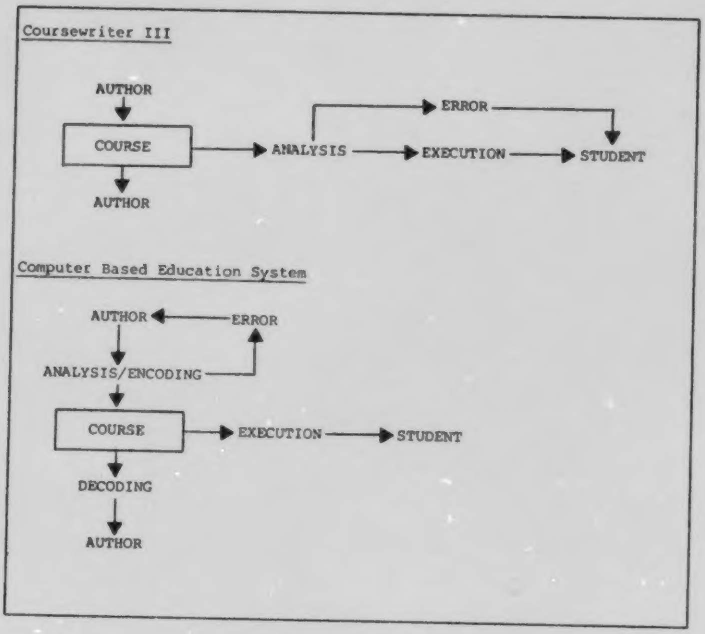
System Operating Logic



A CBE system can be divided into three physical groups: users, a data base, and memory. While processing a student interaction, information passes between the user and memory and between the data base and memory. While in the memory the information can be processed by the computational routines. As each student interaction begins, a portion of the memory is assigned as a work area and information is passed from the user. The computational routines then process the information, formulating a response to be returned to the user. During the computational phase information will be transferred as necessary between the data base and memory. Upon completion of the computational phase, a response will be returned to the user and the memory required for work space released to other users. Since the information transfers occur asynchronously, several can overlap; while one user is awaiting completion of an information transfer, another can be actively processing. Due to the sequential execution of the Coursewriter language, each user need have only one transfer in progress at a given time. As each transfer completes, the computational routine must scan the list of users until it finds the one ready to continue processing. A system designed for 100 users will average 50 checking operations for each information transfer. Assuming a minimum of 2 user transfers and 10 data base transfers per student interaction, (2 + 10) x 50 = 600 checking operations would be required for each student interaction. Since a system designed for 200 users would require (2 + 10) x 100 = 1200 checking operations per student interaction, the total check activity increases exponentially with the addition of users. The only time information transfer from the data base occurs, however, is during the time the user occupies a memory work space. Assuming 10 such work spaces, it is possible to associate data base information transfers with a work space, rather than with a specific user. Utilizing this strategy, 100 checking operations will be required for the 2 user information transfers but only 50 checking operations for the data base information transfers for a total of (2 x 50) + (10 x 5) = 150 checking operations for each student interaction.

Distribution of Processing

A course written in the Coursewriter language consists of a series of instructions stored in the data base. The computation section fetches each instruction, in turn, and performs the action appropriate to it. These statements originate at the author's terminal. The author in the IBM Coursewriter III system enters the statement, the system performs syntax checking and the statement is stored in the data base. This statement can then be retrieved by the author for later reference. During student execution the computational routine fetches the statement, analyzes it, checks for errors, and if no errors are found, executes it. In CBES, the statement analysis is shifted to the author interface. Consequently, most errors are isolated for immediate correction by the author. In addition, statement analysis need be performed only once, rather than each time the statement is executed.


Coursewriter III
AUTHOR
COURSE
AUTHOR
ANALYSIS
ERROR
EXECUTION
STUDENT
Computer Based Education System
AUTHOR
ERROR
ANALYSIS/ENCODING
COURSE
EXECUTION
STUDENT
DECODING
AUTHOR

Redundant Processing

A major method of reducing the computer resources required to support CBE is in minimizing the calculation of often-required values. One such value is the current time of day. It is not unusual for the time, calculated to the nearest minute, to be required for each student interaction. By arranging for the system to calculate the current time only once each minute and saving the result, several hundred calculations are saved each minute.

Reducation of Disk Activity

There are two reasons to fetch information from a data base: (1) because it is needed, and (2) because a copy previously fetched has been overlayed. The first is under the control of the author. The second, while it cannot be eliminated, can be reduced at the system level. Under CBES memory work space can accommodate 4 blocks of course material. When a new block is needed, it overlays the oldest block, allowing retention of the newer ones. An exception to this is a block that will not be reused. These blocks are always overlayed first, allowing retention of 3 potentially reuseable blocks. A fifth block is also provided for non-course material fetches. An additional provision has been made to permanently retain frequently used course blocks in a non-user memory area where all users may access a single copy. This is particularly useful with courses that will have 20 or more simultaneous users.

Locating and Retrieving Information

In a large data base, a major consideration is the ability to find a particular information block quickly and efficiently. To aid in the search, directories are maintained by the system. As the directories become larger, more time is required to search them. To minimize directory search time a technique known as "hashing" is employed. In hashing, the item to be searched is reduced to a numeric value and then divided by the total "slots" in the table. The remainder is the slot number in which to begin the search.

Implementation

Using the aforementioned techniques and principles, CBES was designed and programmed over an 18 month period culminating with its implementation during the Autumn Quarter, 1977. Approximately one-half of the CBE load was assigned to CBES. Operation was very good throughout the quarter, with response times remaining nearly instantaneous even under peak usage. Both down time and instabilities were conspicuous in their absence. Although performance statistics are incomplete, initial studies indicate a reduction in both CPU and disk activity of well over 80 percent.

Enhancements

In addition to reducing the amount of computer resources required, it was desired to increase the accessibility of CBES to both the author and supervisor. Following is a list of enhancements found in CBES:

1. elimination of monitor mode
   All Coursewriter monitor functions are available in author mode.

2. author capabilities available to supervisors
   Supervisor-as-author mode simplifies system maintenance.

3. multiple authors
   A system of interlocks allows the simultaneous sign on of multiple authors on each course.

4. terminal identifier support
   Four character terminal IDs are provided for accurate terminal usage statistics.

5. password protection
   Each student record can be optionally protected with an 8-character password.

6. author-as-student
   The author can specify the use of any student record. By specifying "restart" the author emulates a student sign on.

7. laod/show commands expanded
   All areas of the student record are now accessible.

8. author "debug" mode
   An author can "step" through his program, inspecting and altering his storage facilities at will.

9. control of student sign off
   A student entering "sign off" is branched to label 'end' where the author can provide sign off processing. An additional parameter to inhibit student sign off has also been provided.

10. variable length buffer type
   Position and length may be specified when a buffer is the object of a "ty" operation.

11. additional editing parameters provided

12. editing and prompting during student sign on

13. accountability
   A record of resources required by each user is maintained.

14. stability
   Extensive error recovery and loop detection routines assure system stability.

The development of CBES was forced by the unavailability of other alternatives. At the outset there existed considerable doubt that such a project could be completed with the necessary system stability and savings of resources. As the conversion nears completion, however, it has become apparent that all design goals have been met or exceeded and that the cost-effectiveness of CBE at The Ohio State University has been greatly increased.

Acknowledgements

In a project of this size and duration a number of people, by necessity, become involved. Considerable programming was done by Beverly

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Report of the Computer Assisted Instruction Project in the Faculty of Nursing at The University of Calgary

1. INTRODUCTION

Approximately 18 months ago The University of Calgary, Faculty of Nursing decided to investigate the potential of Computer Assisted Instruction as an alternative teaching strategy for baccalaureate Nursing students. The impetus for this decision came from the report of The Alberta Task Force on Nursing Education. This report to the government of the province of Alberta recommended that, by 1985, authority to certify completion of a program in nursing and thus certify eligibility to write nurse registration examinations will rest only with the two University Schools of Nursing in the province and that by 1990 the minimum requirement for nurse registration should be the baccalaureate degree in nursing. The Task Force Committee further recommended that by 1985 there be two routes to professional nursing preparation: (1) a university-based baccalaureate program, and (2) an articulated baccalaureate program between a non-university setting and a university setting. To accomplish these goals The Task Force has urged the universities and non-university institutions to begin planning immediately for these changes (The Report of the Alberta Task Force on Nursing Education, 1975). It has been projected that by 1980 The University of Calgary, Faculty of Nursing will need to graduate 85 students per year and have a total enrollment of 470 students in order to meet The Task Force recommendation of the baccalaureate degree as the minimum requirement for the professional practice of nursing (Steed, 1976). This represents an increase within three years of almost 200 percent over present enrollment.

Since there are currently no students registered in Nursing Master's programs preparing nursing educators in Alberta, the pool from which to draw qualified faculty is limited. Therefore, there is a need to develop alternative teaching strategies, which facilitate the most effective, efficient, and appropriate use of existing faculty, while maintaining the quality of the programs.

2. PROJECT OVERVIEW

The initial project proposal was for a four phase plan. Phase I was to demonstrate the effectiveness of C.A.I. as an alternative teaching strategy in our setting. The objectives in this phase were:

(1) to evaluate the learning which occurred, the retention of learning and the transfer of learning to the clinical area;
(2) to evaluate the resources available from The University of Calgary Computer Services Division; and
(3) to evaluate the student's receptivity to this mode of learning.

Phase II of the proposal included identification of areas in the curriculum which could be effectively taught using C.A.I., development of a catalogue of available C.A.I. lessons in Nursing and integration of presently available C.A.I. lessons into appropriate locations in the curriculum. In Phase III of the proposal, the goals were:

(1) addition of computer terminals to the Learning Resource Center;
(2) acquisition, purchase, and translation of additional C.A.I. programs from sources identified in Phase II;
(3) adaptation of programs identified in Phase II to meet the objectives of The University of Calgary Nursing curriculum; and
(4) development of additional new C.A.I. programs in nursing at The University of Calgary.

The fourth, or final phase of the proposal and the overall goal of the project consisted of developing and making available C.A.I.-based self study courses for nurses in rural Alberta by which credits towards the Bachelor of Nursing degree at The University of Calgary could be acquired.

A time line was not developed because the phases were conceptualized as being concurrent rather than sequential.

3. PROGRESS TO DATE (PHASE I)

Phase I of the project was begun in September, 1976 with funding from the Research, Policy and Grants Committee of The University of Calgary.

3.1 Methodology

Essentially, the methodology reflects an attempt to replicate the work of M. A. Bitzer (1966; Bitzer and Boudreaux, 1969) with the addition of a tool for evaluating transfer of learning to the clinical area. The population for the study was selected from among volunteer students in the first year of the baccalaureate nursing program at The University of Calgary. The volunteer pool of 35 students was randomly assigned to either the control or experimental group. The two groups of students were taught a unit on the common adaptation problems of Immobility from a Roy adaptation nursing approach (Roy, 1976). The first group of students, constituting the control group, was taught using traditional didactic methods, i.e., lecture-discussion, slides, textbook, illustrative diagrams. The second group of students, constituting the experimental group, was taught the same material using only the C.A.I. program (Bedrest). The computer program consisted of a tutorial program, situation simulation exercises utilizing branching logic, and feedback of corrective teaching to incorrect responses. The program was implemented on the CDC Cyber 172 using the BASIC language. The computer program and the didactic lectures were developed by the same person in order to maintain content equivalence between the two groups of students. The information content was assessed for equality in all aspects by a panel of faculty peers. The two groups of students were taught the units during the same period of time.

Initially, all students were given a teacher-made, paper and pencil multiple choice test (pre-test) consisting of 132 items in order to determine previous knowledge of the material to be covered. At the conclusion of the unit, a parallel, content-equivalent, multiple choice test (post-test) was administered to all students. The tests were given to both groups simultaneously and covered essential concepts and principles relating to the care of immobilized clients. Within one week of completion of the units all subjects were asked to submit an evaluation from the clinical setting of their ability to integrate the principles into nursing care of clients. Thus, transfer of learning to the clinical area was to be evaluated. After six months both groups will be retested to evaluate retention of the information, again by a means of a paper and pencil multiple choice test administered simultaneously to all subjects and by clinical evaluation of all subjects within the same week.

Initially, it was proposed that the paper and pencil tests would provide a learning score for each subject. The mean score within the control group and the experimental group would be calculated and submitted to analysis of variance. Likewise the clinical evaluation instrument was to provide a raw score for each subject and a group mean, and also be submitted to analysis of variance. The assessment of retention would provide two scores (paper and pencil test and clinical evaluation) these were to be averaged to produce one score for each subject. The mean of the averaged scores for each group was to be calculated and subjected to analysis of variance. Thus, F values would be available for learning, for transfer, and for retention.

It was anticipated that the study would provide hard data to support or reject the hypothesis that both teaching methods are equal when total populations are considered. When $p < .05$ the hypothesis would be rejected.

3.2 Results

The lesson material used was readily adapted to this type of presentation. Few difficulties were encountered in the actual programming of the data. The original teaching logic required approximately two months to prepare, and an additional three weeks were required to prepare lesson material in a form suitable for the system. The time for preparation of lesson material could be reduced with experience. A few minor system failures did develop during the experiment, but generally were corrected immediately. However, an interruption of this type tended to create anxiety and frustration in the student. Student frustration also developed as a result of inaccessibility of terminals, since we were limited to use of ten public terminals which were shared with a student body of 16,319. The slow response time on the system was another source of student frustration. Generally, the student response to this learning strategy was highly favorable. Comments included: "a fun way to learn," "let's have more of this," "when will more course work be available on the computer."

An attempt to determine differences in the material learned by the two groups was done by using a t-test of the difference between pre- and post-test scores for the control and experimental groups. The mean score difference between pre- and post-test scores for the control group was 9.89. The mean score difference between the pre- and post-test scores for the experimental (C.A.I.) group was 15.88. This represents a difference of 6.99 between the two groups. This difference between the two groups is significant at the one percent level ($t = .017$) by a two-tailed test. A comparison of the students' Grade Point Averages (G.P.A.'s) for first year of the nursing program revealed no statistically significant difference between the two groups of students. When a scattergram of score differences by G.P.A. was done, no significant trend was identified between the control and experimental groups for students with high G.P.A.'s. However there appeared to be a distinct trend among students with low G.P.A.'s but the total number of students in both the experimental and control groups with low G.P.A.'s was too small (6) to correlate statistically.

A number of problems were encountered in developing a criterion referenced clinical evaluation tool. Efforts to date have been concentrated on developing the tool and establishing its validity and reliability. Testing for retention of learning will be conducted in January of 1978.

3.3 Discussion

The availability of C.A.I. as an alternative teaching strategy within the Faculty of Nursing at The University of Calgary is consistent with the Faculty's belief that "learning can occur through self-directed problem-solving," (Statement on Learning and the Learner, Conceptual Framework, Faculty of Nursing, The University of Calgary, 1976). The results produced by this pilot study have been significant and as such have provided data which justify continued development of the C.A.I project as an integral part of the curriculum in the Faculty of Nursing. The data also indicate directions for further study, particularly in terms of the type of student who learns best using a specific learning strategy. This portion of the project will be replicated with a larger population and will include study of the transfer of learning to the clinical situation with the tool developed in this pilot study.

4. PROGRESS TO DATE (PHASES II, III, IV)

Phase II (which was to identify areas in the curriculum which could be effectively taught using C.A.I. and to identify C.A.I. lessons in nursing available from other sources) is presently in the initial stages. The curriculum blueprints are being studied and learning modules are being developed in several courses. C.A.I. has been introduced as an integral portion of selected courses (as opposed to a research or add-on approach). We anticipate undertaking, shortly, a survey of all baccalaureate Schools of Nursing in Canada and the United States to inventory nursing C.A.I. and the willingness to exchange lessons.

Phase III, acquisition of terminals for our Learning Resource Center has been accomplished. The terminals are either in place in the Learning Resource Center or on order with delivery anticipated momentarily. The acquisition of lessons from other sources has not begun because the inventory of lessons (in Phase II) is incomplete. New lessons are under development by several faculty members. While this development might not result in highly sophisticated lessons, in the process the faculty is acquiring experience which, hopefully, will develop into sophistication and expertise.

Preliminary discussions have been undertaken with one of the local hospitals regarding Phase IV. The discussions have centered around the philosophy which will underlie a delivery mechanism for C.A.I.-based courses for credits towards the baccalaureate degree in Nursing at The University of Calgary.

SUMMARY

Since August of 1976, the Faculty of Nursing, The University of Calgary has developed and implemented a four phase, C.A.I. project as follows:

Phase	Goal(s)	Progress
I	Demonstrate effectiveness of C.A.I. as alternative teaching strategy in our setting.	Pilot project completed. Replication on-going.
II	1. Identification of areas in curriculum which could be effectively taught using C.A.I.	Currently being surveyed.
	2. Inventory of Nursing related C.A.I. existing in North America.	To begin January, 1978.
III	1. Addition of computer terminals to Faculty of Nursing, Learning Resource Center.	Accomplished.
	2. Acquisition of C.A.I. lessons from external sources.	Awaiting completion of Phase II, Goal 2.
	3. Development of C.A.I. lessons by The University of Calgary, Faculty of Nursing.	In progress.
IV	Delivery to nurses in rural Alberta of C.A.I.-based courses for credit towards the baccalaureate degree in nursing at The University of Calgary.	Preliminary discussions re delivery mechanism undertaken.

References

Bitzer, M. A. "Clinical Nursing Instruction Via the Plato Simulated Laboratory," Nursing Research, Volume 15, No. 2, Spring 1966, pp. 144-150.

Bitzer, M. A. and M. C. Boudreaux. "Using a Computer to Teach Nursing," Nursing Forum, Volume VIII, No. 3, 1969, pp. 234-254.

Report of the Alberta Task Force on Nursing Education. Department of Advanced Education and Manpower, Edmonton, Alberta, 1975.

Roy, Sister Callista. Introduction to Nursing: An Adaptation Model. Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1976.

"Statement on Learning and the Learner," Conceptual Framework. Faculty of Nursing, The University of Calgary, Calgary, Alberta, 1976.

Steed, M. Response to the Report of the Alberta Task Force on Nursing Education. Faculty of Nursing, University of Alberta, Edmonton, Alberta, 1976.

MCAID - A Generalized Text Driver

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MCAID

(McMaster Computer-aided Instructional Driver)

MCAID is a programming technique to derive a text-file with instructional frames and embedded branching logic and allows calls to compiled subroutines to perform extensive calculations. It has been specially developed to incorporate text-authoring around the physiological models MACMAN, MACPUF and MACPEE. However, the approach is quite general and machine-independent.

1. INTRODUCTION

The recent years have witnessed a great deal of activity in the area of computer-aided instructions (CAI)(1). A variety of languages(2) and systems have evolved to provide authors with means for developing teaching and evaluation programmes. Existing programming languages have also been employed for this purpose. The existing CAI material can be classified into two broad categories viz., programmed text and computational (or simulation) programs. The first of these allow extensive text-handling and convenient control of branching logic but offer limited or no computational facility. The IBM Coursewriter (3) is a good example of this approach - it provides an excellent text-handling facility, however, it is difficult if not impossible to write a teaching program in such a language which will branch the student to a computational subroutine or a simulation program to perform complex computations. MUMPS(4) interpreter is another example of such a language which has many convenient text-handling features but limited precision and speed in arithmetic operations. The second approach, using commonly available programming languages such as FORTRAN, BASIC, PL/1 etc. allow an author to design complex mathematical models to explore a specific subject area. The Mac Family of Physiological models(5-8) MACMAN, MACPUF, MACPEE and MACDOPE are examples of this approach. However, these type of programs have limited text-handling since FORTRAN, BASIC, etc. are not primarily designed for text-handling and require large amount of computer memory for text formatting.

The two approaches, therefore, are contradictory, providing either text-handling facilities or computational capabilities but not both. In addition, they are generally machine-dependent and teaching material is seldom adaptable to different machines.

We have developed a driver program which combines both the objectives.

It is presently programmed in FORTRAN but can easily be adapted to other languages which allow direct-access read/write facilities on disc files. All the text material and its branching logic are stored on a card-image text-file. It can call compiled subroutines to perform special calculations and simulations. The overall branching is monitored by the MCAID driver (Fig. 1).

The need for such a system was recognized after we had developed the physiological models in FORTRAN. These models enabled a variety of experiments of human physiology but had very limited dialogue facility to explain or query the student about the simulations. The programs, therefore, did not always achieve full education potential. We feel that we have overcome this problem by the development of MCAID.

2. MCAID AND THE TEXT-FILE

The computational routines to be used in a CAI package are written in a programming language such as FORTRAN and compiled into a library accessible to the MCAID driver. The driver consists of several small routines (totalling about 600 FORTRAN statements). It drives the text-file and calls compiled subroutines when necessary (Fig. 1).

All the text material and the associated branching logic is contained in a card-image text-file which resides on disc. This file is organized into several frames, each of which contains several lines of text material and a unique branching logic, characterized by the frame-type. There are 10 types of frames which will be described in some detail in the next section. The three most important frame types are the Q-frame(question-frame with conditional branch based upon the response); the T-frame (text-frame with unconditional branch) and the S-frame (subroutine-frame, calls a specified subroutine).

Normally the driver starts execution at a specified frame (the Begin-frame) and branches forward or backward to any frame in the text-file depending upon the user response and the branching logic of the current frame. When an S-frame is encountered, the driver determines the subroutine number to be called. It then calls a specific subroutine MCSUB which then relates this number to the appropriate subroutine from a list of library routines and calls the subroutine. Upon return, the driver determines the next frame number to be executed (out of one or more possible candidates) and transfers control to that frame. MCSUB, therefore, acts as a window through which the driver communicates with the compiled subroutines for a particular teaching program. These subroutines can be used for any conceivable purpose such as mathematical calculations, randomization, special string-handling, plotting graphs, etc. etc. It is this feature that enhances the power of MCAID.

3. FRAME-TYPES

The MCAID text material is stored on a text-file consisting of an arbitrary number of frames. Each frame has a unique number and branching logic and may contain several lines of text. A typical Q-frame is illustrated in Figure 2. The execution of this frame proceeds as follows. After displaying the text lines from this frame, the driver accepts input from the terminal. If the answer is "YES" a branch to frame number 200 will be made, if the answer is "NO" a branch to frame 80 will be made. It is also possible to allow for numeric response or null response (i.e. match any answer).

There are 10 frame-types in MCAID. Briefly, their functions are:

T-FRAME	Contains descriptive text and an unconditional branch to another frame in the text file.

Q-FRAME	Contains multiple-choice questions and a list of possible frames to branch to.
S-FRAME	Contains text and a subroutine No. to be called. The driver locates this subroutine and activates it; upon return the driver passes control to a specified frame.
D-FRAME	A dummy frame which does not have its own branching logic but contains text lines which can be used by other frames.
B-FRAME	Specifies the starting frame in the lesson.
E-FRAME	Specifies the end frame - terminates the program.
G-FRAME	Specifies global keywords (such as 'STOP', 'HELP') checked against all responses, and corresponding frames to branch to.
F-FRAME	Set flag to a specified value.
I-FRAME	Branch to a frame if the flag has a specified value.

4. CONCLUSIONS

We have developed a relatively machine-independent technique for writing computer-aided instructional material consisting of descriptive text, multiple-choice questions and the ability to call compiled subroutines to perform complex computations. The MCAID driver is programmed in FORTRAN (about 600 statements) and can be adapted to other programming languages. The driver however, relies heavily on the ability to perform random access read/write on a card-image disc file, which contains all the text material and the branching logic.

A simplified flowchart of the driver appears in Appendix A. An example of a typical text-file is shown in Appendix B. Example of a typical student dialogue appears in Appendix C.

The driver has been successfully used at McMaster University to develop teaching and evaluation programs around complex physiological models. It has also been used to adapt CAI material developed elsewhere to a mini-computer, which would have been impossible otherwise.

We feel that the MCAID approach offers a convenient means of combining text-material with extensive computations on most computers. The author can prepare his text material on special forms which are easily coded and transferred to a disc file (e.g. by means of keypunched cards or a text-editor).

FORTRAN source listing of the driver, example of text-file and author forms are available from the first author. A technical manual is in preparation.

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REFERENCES

1. Brigham,C.R., Kamp,M. and Cross,K.J. - "A Guide to Computer Assisted Instructions in Health Sciences", report prepared for the Lister Hill National Centre of Biomedical Communications, National Library of Medicine, by Rutgers Medical School, Piscataway, N.J. and Office of Information Systems, University of California at San Francisco (1975).

2. Brigham, C.R. - "Programming Languages Used for Health Sciences Computer Assisted Instructions", report prepared for the Lister Hill National Center for Biomedical Communications, National Library of Medicine, by Harvard Medical School, Boston, Mass. and Laboratory of Computer Science, Massachusetts General Hospital, August 1973.

3. COURSEWRITER III for System/360 (Version 2) - Author's Guide, IBM Publication No. (360A-UX-01X).

4. Bowie,J. and Barnett, O. - "MUMPS - An Economical and Efficient Time-sharing System for Information Management", Computer Programs in Biomedicine, _6_, pp 11-22 (1976).

   O'Neil, J.T. - Editor, "MUMPS Language Standards", NBS Handbook 118, U.S. Government Printing Press, Wasington D.C., 20402 (1976).

5. Dickinson, C.J., Goldsmith, C.H., and Sackett, D.L. - "MACMAN: A Digital Model for Teaching some Basic Principles of Haemodynamics", J. Clin. Computing, Vol.2,_4_,(1973), pp42-50.

6. Dickinson, C.J. - "A Computer Model of Human Respiration - MACPUF" - University Park Press, Chamber of Commerce Bldg., BALTIMORE, Md., 21202. (1977).

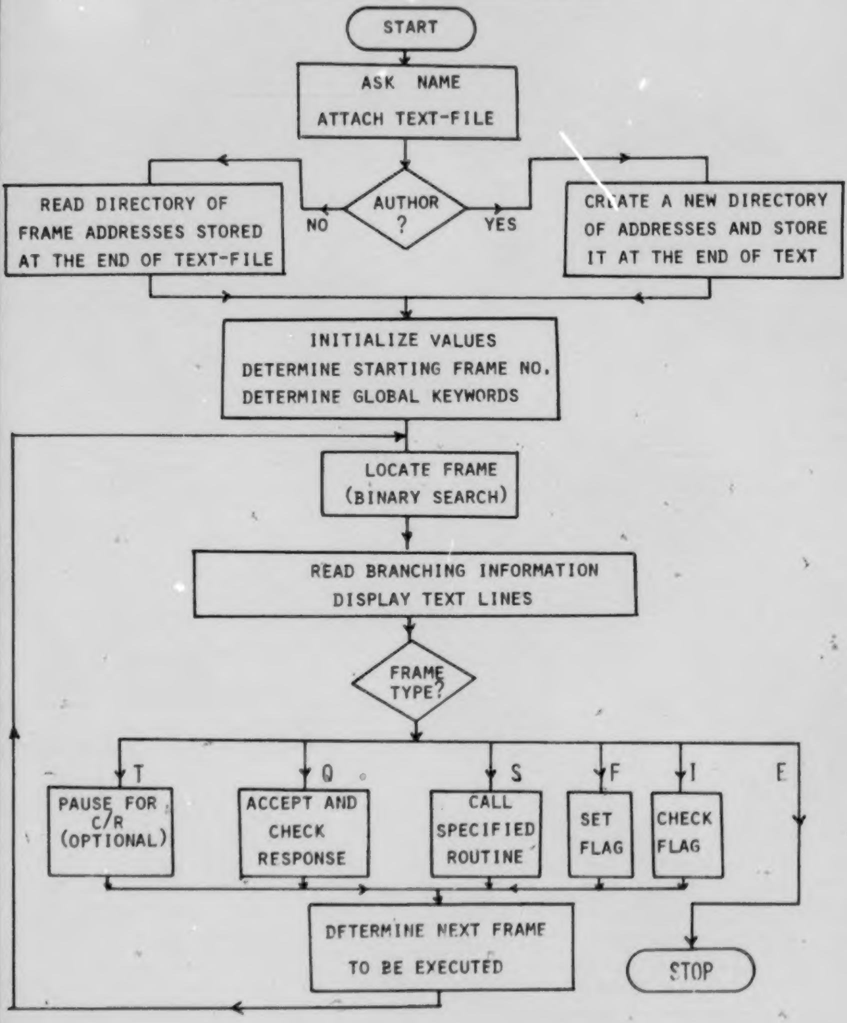
REFERENCES (contd.)

7. Dickinson, C.J., "A digital computer model of the Systemic Circulation and Kidney, for studying Renal and Circulatory Interactions involving Electrlytes and Body Fluid Compartments - MACPEE", J. of Physiology, London, Vol 216 (1971), pp 11-12.

8. Bloch, R., Sweeney, G. S., and Ahmed, K.- "MACDOPE: Computer Simulation of Pharmacokinetics", McMaster University Medical School, Hamilton, Ont. L8S 4J9, Canada (1976).

APPENDIX A

FLOW OF CONTROL OF THE MCAID DRIVER


START
ASK NAME
ATTACH TEXT-FILE
AUTHOR ?
NO
YES
READ DIRECTORY OF FRAME ADDRESSES STORED AT THE END OF TEXT-FILE
CREATE A NEW DIRECTORY OF ADDRESSES AND STORE IT AT THE END OF TEXT
INITIALIZE VALUES
DETERMINE STARTING FRAME NO.
DETERMINE GLOBAL KEYWORDS
LOCATE FRAME (BINARY SEARCH)
READ BRANCHING INFORMATION
DISPLAY TEXT LINES
FRAME TYPE?
T
Q
S
F
I
E
PAUSE FOR C/R (OPTIONAL)
ACCEPT AND CHECK RESPONSE
CALL SPECIFIED ROUTINE
SET FLAG
CHECK FLAG
DETERMINE NEXT FRAME TO BE EXECUTED
STOP

APPENDIX B

EXAMPLE OF A TEXT-FILE

```
*A    1  555
*G "STOP",900 "OPTIONS",9
*C-------------------------------------------------------------------------
*C
*C               MCMNTEXT  (MCAID TEXT FOR MACMAN PROBLEMS)
*C
*C AUTHORS: DR.K.AHMED, DR.C.J.DICKINSON & DR.G.D.SWEENEY
*C          COMPUTATION SERVICES UNIT,
*C          MCMASTER UNIVERSITY MEDICAL SCHOOL, HAMILTON, ONT., CANADA
*C          AUGUST 1976
*C-------------------------------------------------------------------------
*Q  1 0  'Y',9  'N',2
    THIS PROGRAM INTRODUCES YOU TO THE PHYSIOLOGICAL MODEL 'MACMAN' BY
 MEANS OF SOME SIMPLE EXAMPLES AND ALLOWS YOU TO PERFORM YOUR OWN
 SIMULATION EXPERIMENTS.
 HAVE YOU USED THIS PROGRAM BEFORE? (ANSWER Y OR N AND PRESS 'RETURN')
*T  2 0 0 1000
 THIS MATERIAL WAS DEVELOPED BY DRS.K.AHMED, C.J.DICKINSON & G.D.SWEENE
 AT MCMASTER UNIVERSITY. IT HAS THREE GOALS:-
 (1) TO INTRODUCE YOU TO A COMPUTER SIMULATION OF RAPID CARDIOVASCULAR
     RESPONSES IN MAN.
 (2) TO TEACH YOU THE BASIC PRINCIPLES OF SYSTEMIC HEMODYNAMICS.
 (3) TO ALLOW YOU TO TEST YOUR UNDERSTANDING OF THE CIRCULATION OF
     MAN, AND YOUR SKILL IN ANALYSING DIFFICULT PROBLEMS.
*T  4 0 0 5
 I SHALL TAKE YOU INTO THE MODEL AND OFFER YOU A NORMAL(INTACT) SUBJECT
 YOU CAN THEN CHANGE ANY OF THE FIVE FACTORS (E.G. BLOOD VOLUME) AND
 SEE THE EFFECTS.
    WHEN YOU ARE ASKED THE QUESTION 'DO YOU WANT TO 1.CHANGE, 2.CONT..'
 FIRST ASK FOR '1.CHANGE ' & PRESS RETURN, THEN '1.CHANGE VALUES' (PRES
 RET). THEN ENTER '5' (FOR BLOOD VOL.), PRESS RET, THEN PUT IN THE NEW
 VALUE FOR FACTOR 5 (BLOOD VOL IN MLS.). FINALLY, ASK FOR '2.CONTINUE'.
 ......IT WILL LOOK A LOT SIMPLER ONCE YOU HAVE DONE IT!  WHEN YOU ARE
 READY TO COME BACK TO TALK TO ME SPECIFY 'STOP THE MODEL'.
*S  5 0 5  6
*C << CALL MACMAN, OFFER NORMAL SUBJECT AND ALLOW INTERACTION >>
*Q  6 0 (1)8 (2)900
 I HOPE YOU HAVE GOT A GOOD IDEA OF WHAT THE MODEL CAN DO FOR YOU.
 IF YOU HAVE ANY PROBLEMS IN THE DISCUSSION SO FAR, PLEASE FIND A
 RESOURCE PERSON WHO CAN HELP, OR CONSULT THE 'MACMAN HANDBOOK' WHICH
 CONTAINS A FAIRLY DETAILED ACCOUNT OF THE MODEL AND HOW TO USE IT.
 SHALL WE  1.PROCEED FURTHER, OR  2.STOP AT THIS POINT?
*Q  8 0 'Y',10 'N',9
 IF YOU WISH YOU CAN GO BACK TO THE MODEL AND TRY DIFFERENT VALUES OF
 BLOOD VOLUME AND GRAPH THE BLOOD PRESSURE AND HEART RATE, OR FOR THAT
 MATTER DO ANY OTHER EXPERIMENTS. WOULD YOU LIKE TO DO THAT?
*C-------------------- CENTRAL CONTROL POINT ------------------------------
*Q  9 0 (1)10 (2)20 (3)400 (4)320 (5)900
 SINCE YOU ARE FAMILIAR WITH THE USE OF THE MODEL PATIENT 'MACMAN',
 I CAN OFFER YOU FIVE CHOICES:
   1.JUST TO CALL UP THE MODEL AND PERFORM ANY EXPERIMENTS YOU LIKE.
   2.TO EXPLORE THE ROLE OF NERVOUS REFLEXES IN PROTECTING THE
     CIRCULATION FROM THE ILL EFFECTS OF MODERATE HAEMHORRHAGE.
   3.TO TEST YOUR UNDERSTANDING OF THE SYSTEMIC CIRCULATION BY A
     SEARCHING EVALUATION EXCERCISE IN PROBLEM SOLVING.
```

```
  1..ART. RESISTANCE=  100.0 PC OF NORMAL
  2..VEN. RESISTANCE=  100.0 PC OF NORMAL
  3..CARDIAC CONTRACTILITY=  100.0 PC OF NORMAL
  4..MEAN INTRATHORACIC PRES.=  -2.0 MM HG
  5..BLOOD VOLUME=  5000.0 ML

  IF YOU DON'T UNDERSTAND WHAT THESE FACTORS MEAN OR WHAT THEY CONTROL
*Q 1030 0 'GO',1090 '1',1040 '2',1050 '3',1060 '4',1070 '5',1080
 TYPE THE FACTOR NUMBER.  WHEN YOU WANT TO PROCEED FURTHER TYPE 'GO'.
*T 1040 0 1 1030
 ARTERIAL RESISTANCE IS A MEASURE OF THE PRESSURE REQUIRED TO DRIVE
 BLOOD THROUGH THE SYSTEMIC CIRCULATION AT A DESIRED RATE.BLOOD PRESSURE
 CAN BE VIEWED AS THE PRODUCT OF CARDIAC OUTPUT AND ARTERIAL RESISTANCE:
 IF ARTERIAL RESISTANCE IS INCREASED MUCH ABOVE NORMAL, HYPERTENSION
 RESULTS:  IF IT IS MUCH BELOW NORMAL,  SHOCK MAY ENSUE.
*T 1050 0 1 1030
 ONLY A SMALL PRESSURE IS NEEDED (OR AVAILABLE) TO PUSH BLOOD THROUGH
 THE VEINS BACK TO THE HEART. BUT VENOUS RESISTANCE IS NEVERTHELESS
 IMPORTANT IN DETERMINING RETURN OF BLOOD TO THE HEART.  AN INFERIOR
 VENA CAVA OBSTRUCTION MAY WELL INCREASE VENOUS RESISTANCE
 DRAMATICALLY.
*T 1060 0 1 1030
 "CONTRACTILITY" DESCRIBES THE EFFECTIVENESS OF THE HEART'S MUSCULAR
 ACTION - OBVIOUSLY IT IS DECREASED IN INFARCTION.
*T 1070 0 1 1030
 DUE TO VARIOUS FACTORS RELATING TO THE MECHANICS OF BREATHING, THE
 AVERAGE PRESSURE WITHIN THE CHEST IS NEGATIVE AND THIS HELPS GET BLOOD
 BACK TO THE HEART. IF YOU PUT A PATIENT ON A RESPIRATOR THIS NO LONGER
 APPLIES.
*T 1080 0 1 1030
 IF YOU DON'T KNOW WHAT BLOOD VOLUME IS YOU SHOULD NOT BE IN MEDICAL
 SCHOOL!
*Q 1090 0  'Y',4   'N',9
 O.K. - SO YOU KNOW THAT 'MACMAN' ALLOWS YOU TO DO EXPERIMENTS ON A
 SIMULATED HUMAN. IT PRINTS OUT BLOOD PRESSURE AND PULSE RATE READINGS
 EVERY TWO SECONDS AS THE CARDIOVASCULAR SYSTEM ADAPTS RAPIDLY TO
 CHANGES IN IMPORTANT THINGS SUCH AS THE AMOUNT OF BLOOD.
 IN ADDITION EXACT FIGURES WILL BE GIVEN TO YOU FOR THESE FACTORS.
 HOWEVER, WHEN YOU CHANGE THE FACTORS NO PRIOR KNOWLEDGE OF NUMBERS
 IS REQUIRED.
 DO YOU WANT TO DO AN EXPERIMENT? (ANSWER YES OR NO)
************************************************************************
 111
 900   2   1  12   2  17   4  25   5  35   6  37   8  43   9  48  10  60
  20  65  30  74  40  76  50  82  60  84  70  90  80  98  90 102 100 105
 110 113 120 115 122 124 124 126 126 128 128 130 130 132 140 136 150 138
 156 147 160 154 170 158 172 160 180 162 190 173 200 177 210 180 220 187

 700 420 710 422 730 426 740 439 750 442 760 444 770 449 800 457 810 459
 830 463 900 4691000 4721010 4931020 5061030 5201040 5221050 5281060 534
1070 5371080 5421090 545
SSSSSQQDQDTQSQQTTQTTTQTTQTTED
```

(Note: The directory of frame addresses is stored in the text-file after the last frame. A simple binary search on this table is done to locate a particular frame).

APPENDIX C

A TYPICAL EXAMPLE OF STUDENT DIALOGUE WITH MCAID (using MacMan)

```
   THIS PROGRAM INTRODUCES YOU TO THE PHYSIOLOGICAL MODEL 'MACMAN' BY
MEANS OF SOME SIMPLE EXAMPLES AND ALLOWS YOU TO PERFORM YOUR OWN
SIMULATION EXPERIMENTS.
HAVE YOU USED THIS PROGRAM BEFORE? (ANSWER Y OR N AND PRESS 'RETURN')
? NO

THIS MATERIAL WAS DEVELOPED BY DRS.K.AHMED, C.J.DICKINSON & G.D.SWEENEY
AT MCMASTER UNIVERSITY. IT HAS THREE GOALS:-
(1) TO INTRODUCE YOU TO A COMPUTER SIMULATION OF RAPID CARDIOVASCULAR
    RESPONSES IN MAN.
(2) TO TEACH YOU THE BASIC PRINCIPLES OF SYSTEMIC HEMODYNAMICS.
(3) TO ALLOW YOU TO TEST YOUR UNDERSTANDING OF THE CIRCULATION OF
    MAN, AND YOUR SKILL IN ANALYSING DIFFICULT PROBLEMS.
<PRESS RETURN>
?

I ASSUME YOU HAVE NOT USED 'MACMAN' BEFORE.  THIS IS A MODEL OF THE
HEART AND SYSTEMIC CIRCULATION DESIGNED TO ILLUSTRATE RAPID HOMEO-
STATIC RESPONSES.  LET US TAKE A NEW PATIENT. HERE IS A PRINT-OUT OF
BLOOD PRESSURE (XXXX) AND PULSE RATE (....) OF A NORMAL SUBJECT FOR
THE PAST 30 SECONDS.  NOTE THAT THE TIME AXIS IS VERTICALLY DOWNWARD.

TIME 0   20  40  60  80  100 120 140 160 180 200 220 240 260 280 300
SECS .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 -28               .XXXXXXXXX
 -24               .XXXXXXXXX
 -20               .XXXXXXXXXX
 -16               .XXXXXXXXXX
 -12               .XXXXXXXXX
  -8              .XXXXXXXXXX
  -4               .XXXXXXXXXX
   0               .XXXXXXXXXX

IF IN YOUR MIND YOU TURN THE GRAPH 90 DEGREES ANTICLOCKWISE, IT
BECOMES A STANDARD B.P. AND PULSE CHART, WITH TIME (IN
SECONDS) ALONG THE BOTTOM.
<PRESS RETURN>
?

OBVIOUSLY NOT MUCH IS GOING ON AT PRESENT:  PULSE AND BLOOD PRESSURE
ARE STABLE. HOWEVER,THIS RESULTS FROM THE INTERACTION OF MANY DIFFERENT
FACTORS AND THE SECOND PART OF A 'MACMAN' PRINT-OUT IS A LIST OF
PHYSIOLOGIC VALUES OPERATING WHEN THE LAST READING FOR BLOOD PRESSURE
APPEARED HERE IN THE PRINT-OUT: DON'T BOTHER WITH THE FIGURES AT THE
MOMENT: OUR OBJECTIVE IS TO HELP YOU LEARN WHAT THESE MEAN.

B.P. SYSTOLIC=121  DIASTOLIC= 76  MEAN=  91.3
RIGHT ATRIAL PRESS.= 1.7 MM HG  MEAN CAPILL.PRESS.=    12.7 MM HG
CARDIAC OUTPUT=  5.0 L/MIN, STROKE VOL.= 68.0 ML, HEART RATE=  73.
ART.RESIST.=  16.0   VENOUS RESIST.=  2.2 MM HG/L/MIN
CARDIAC CONTRACTILITY=  1.3 L/MIN/MM HG FILLING PRESS.
<PRESS RETURN>
?

 'MACMAN' IS A RESILIENT FELLOW AND WELCOMES EXPERIMENTS HOWEVER
UNETHICAL. YOUR EXPERIMENTS MAY KILL HIM BUT REINCARNATION IS
IMMEDIATE! THE FACTORS YOU CAN ALTER IN DOING EXPERIMENTS ARE LISTED
BELOW: THE VALUES SHOWN ARE THOSE AT THE END OF THE RUN GRAPHED OUT
ABOVE.

1..ART. RESISTANCE=  100.0 PC OF NORMAL
2..VEN. RESISTANCE=  100.0 PC OF NORMAL
3..CARDIAC CONTRACTILITY=  100.0 PC OF NORMAL
4..MEAN INTRATHORACIC PRES.=  -2.0 MM HG
5..BLOOD VOLUME=  5000.0 ML

IF YOU DON'T UNDERSTAND WHAT THESE FACTORS MEAN OR WHAT THEY CONTROL
TYPE THE FACTOR NUMBER.  WHEN YOU WANT TO PROCEED FURTHER TYPE 'GO'.
```

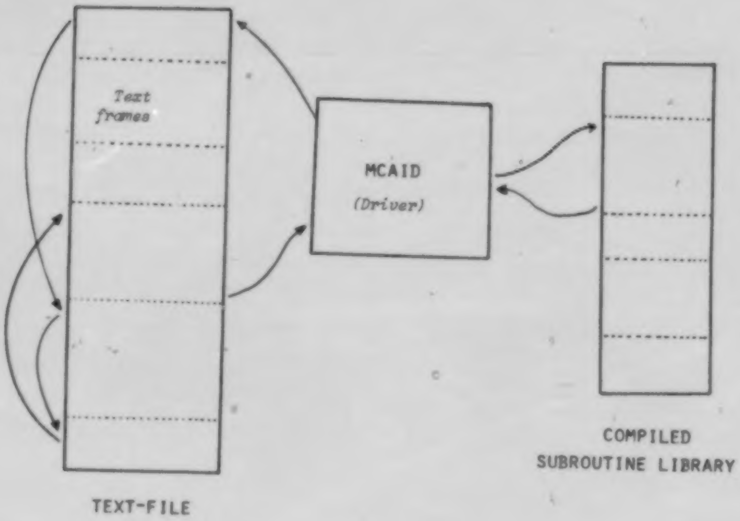

Text frames
MCAID
(Driver)
COMPILED SUBROUTINE LIBRARY
TEXT-FILE

Fig.1 - COMPONENTS OF MCAID. The text material and the associated branching information is contained on the text-file. Computational routines reside in the compiled library. MCAID driver monitors over-all control.

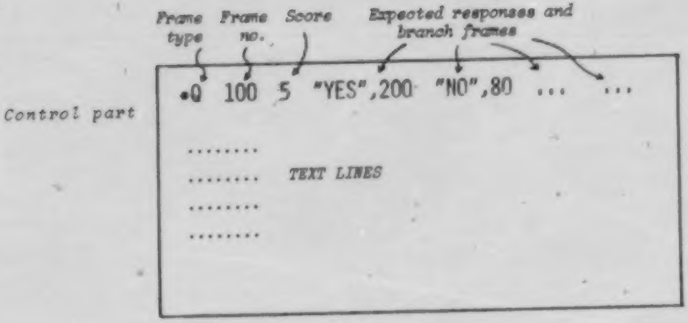

Frame type
Frame no.
Score
Expected responses and branch frames
*Q 100 5 "YES",200 "NO",80 ... ...
Control part
....
.... TEXT LINES
....
....

Fig. 2 EXAMPLE OF A TYPICAL Q FRAME

NAME: Pat Sturdivant
PROJECT: Region IV Education Service Center - CAI
LOCATION: Houston, Texas
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Region IV Education Service Center is an intermediate state agency that provides a variety of educational services to schools in the greater Houston area. One of the many programs available to area schools is computer assisted instruction (CAI). Region IV, designated as a Multiregional Processing Center (MRPC), has the responsibility for meeting the computing needs of 101 school districts in the Gulf Texas Area. One-third of these districts are using CAI. In terms of hardware, this regional computing network consists of 31 remote job entry terminals, 14 minicomputers and 480 instructional terminals linked to a twin Cyber 172 central processing unit.

At the present time, there are about 7,000 elementary and secondary students who are receiving computer assisted instruction. Contractual arrangements with the districts vary, but most of them choose to lease both hardware and software from Region IV. Timesharing allows them the flexibility of contracting for a single CAI course or for several programs of their choice which are available in drill and practice, tutorial, dialogue and simulation modes. A wide range of instructional programs are available in grade levels ranging from 1-12 in areas such as reading, language arts, math, social studies and science. An Occupational Data Bank and the Guidance Information System (GIS) are available for career exploration.

Region IV provides both technical and curricular support to the districts. While most of the schools contract for both equipment installation and maintenance, they also receive a number of support services. The most important of these is staff training. Needless to say, the effectiveness of any new program hinges on the attitudes of the people who are responsible for working with it. In the case of CAI, training is especially important because this innovation can be potentially threatening to classroom teachers, especially if they are not properly oriented to the role of the computer as a supportive teaching tool. Region IV provides a continuous inservice program designed to help teachers and administrators successfully integrate CAI with the regular developmental program. The staff receives training in the use of computer generated reports that can help them in instructional planning and evaluation. Compatability of the CAI courseware with existing curricula is investigated in training sessions along with classroom management strategies.

One of Region IV's efforts in staff development involves the training of classroom teachers working with PLATO at six elementary and secondary schools. In this pilot project, teachers have been inserviced in the utilization of PLATO curriculum so that they can better meet the educational needs of students identified as gifted and talented. Another pilot project involves about 800 adults in a community education program. These adults are learning skills that will enable them to pass the GED exam so that they can obtain the high school equivalency certificate. Their instructors are taught how to interpret the computer generated profiles on individual students so that they can tutor the adults in needed prerequisites.

Assistance with program evaluation also represents an ongoing communication and program support effort. One of the most frequently noted problems identified in the literature on CAI is the lack of data documenting the effectiveness of CAI applications. Schools served by Region IV receive a statistical analysis of student achievement gains on a quarterly basis. Administrators are provided with mean achievement gains and a variety of cross tabulation reports to help them monitor the progress of their students. Management reports have also been developed for the drill and practice programs. These reports alert teachers to the names of students not making expected progress and pinpoint specific "troublespots" that individual students may be having in specific skill areas. This kind of information helps facilitate flexible skill grouping for the purposes of instructional management. Other report products communicate information to parents and teachers about student progress. Certificates of Progress and Certificates of Participation can be produced for individual students. These report the amount of achievement gain each student has made in the CAI Program.

While it may be several years before mass implementation of CAI becomes a reality, planning should begin now. In implementing any new innovation, there must be some consideration given to adapting it to the needs of the user if it is to be successfully integrated into a school's operating system. Computers have the potential for making a significant impact on the educational establishment and an intermediate state agency can help promote this development.

ABSTRACT

Progress Report on the activities of the University of Tennessee Center for the Health Sciences (UTCHS) Computer-Based Educational (CBE) group.

John E. Baxter, C. Coe Agee and T. Earle Bowen, Office of Educational Resources and Department of Biochemistry, Memphis, Tennessee 38163.

Efforts to provide a Computer Based Educational capability at UTCHS were inaugurated in 1973 with the creation of software and lessonware on our PDP 11/20 to drill medical students in the mysteries or acid-base equilibrium and amino acid sequencing. In 1974 UTCHS entered into a cooperative agreement with the School of Basic Medical Sciences of the University of Illinois, Urbana, to develop lessonware on the PLATO IV system. The exposure to CBE provided by this arrangement generated considerable interest within our faculty and our student body. However, with only two terminals to serve about 2000 students in the colleges of basic sciences, medicine, pharmacy, nursing, dentistry and allied health, we have not attempted to promote CBE as an integral part of any course; rather we have allowed it to serve as an auxillary resource. Beginning in 1976, the Department of Biochemistry elected to include references to relevent CBE lessonware in the curriculum syllabus for the first year medical students. Response was so favorable that funds were provided to purchase one printing terminal and two additional PLATO V terminals which are slated for installation in early January 1978. Our major thrust, though, will be in the area of computer manage instruction (CMI). In the Winter and Spring of 1978, we intend to offer two, and possibly three, independent study courses managed through our CMI system. Currently, we are exploring the implementation of a so-called multi-purposed terminal; one which is capable of accessing ASCII systems, PLATO systems, and/or functioning in a stand alone mode. We are also developing hardware and software to interface our PLATO V terminals to our "in-house" PDP 15 computer system.

PLATO MUSIC SYSTEMS

by Sherwin Gooch
Computer-based Education Research Laboratory
University of Illinois at Urbana-Champaign

The PLATO music project is rooted in a conjecture which is perhaps best stated in this manner: Johann Sebastian Bach may have been one of the greatest composers of all time due, in part, to his magnificent performing abilities. Performing ability is important in the original training of a composer's ear, and in the later maturation of this skill into the ability to "visualize" form in aural space. Performing ability is also of critical importance when the composer acts as a "passive observer", listening to his own performance of a composition, with the goal of later improving it. This is a feedback process wherein the composer specifies an action, and monitors the outcome. He then modifies the specifications, and repeats the feedback process until, if the labor is fruitful, the process converges to some preconceived form, and the piece is complete.

The original PLATO music concept was to replace the human performer in the feedback loop described above with a computer-controlled device. The first device of this type which was developed is known as the Gooch Synthetic Woodwind (GSW). The GSW represents a rudimentary attempt to provide, at minimum cost, some of the features needed in an interactive compositional facility, as well as many of those needed for computer-based music instruction.

The GSW provides nearly instantaneous control over the pitch and amplitude of four independent voices. (A voice is the electronic equivalent of a human voice in that it reproduces a single line of music.) Eight levels of volume are provided, which is sufficient to separate voices into solo and accompaniment, although it severely limits attempts to employ dynamics in a composition. The increments in pitch which the computer may specify are small enough to facilitate study of alternative tunings, including Just intonation in rapidly changing keys, and scales containing other than twelve tones.

Even within these limitations, this design philosophy seems to have met with some success. At the time of this writing, there are over fifty of these devices in use. They are being used for interactive ear-training drill, music dictation exercises, and in some compositions[1]. They also seem to have fostered a new artistic medium, which we refer to as "interactive art". In interactive art, the actions of the observer, sitting at a PLATO terminal, influence the performance of the composition. In the past, such experiences have been available only to conductors and solo performers.

Controlling even a device which is as conceptually simple as a GSW can be a horrendous programming task when the control is established through an interactive graphics computer system that is in a state of evolutionary flux. We estimate that only around ten percent of the human effort expended in the PLATO music project has gone into hardware-related activities; the other ninety percent of the effort has been in activities related directly to the generation and maintenance of software. The PLATO Music Group has concentrated its efforts on generating only the most basic programs needed to interface to music hardware, often providing only bare-bones examples of how courseware may be written, and leaving the monumental task of generating the actual PLATO courseware to the experts in the field.

At each evolutionary step, we try to provide what the PLATO community refers to as "author helps". This means that we provide easily-accessible, on-line, in-depth documentation of music hardware and software, as well as programs and program segments which will aid a PLATO author in writing courseware which utilizes PLATO music devices. In the case of the GSW, we developed a PLATO-compatible music language, a compiler for this language, two music text editors, a filing system for music binaries, and programs to play the music binaries in real time, as well as many debugging and compositional aids. The resulting subsystem is such that a PLATO author may type in a segment of music in a high level language, and have it played for his students by essentially "calling" a routine with the name that s/he gave the segment when the compiler stored the music binary, and the name of the "dataset" in which the binary is located. See figure one for an example of the source code for the language which has been developed.

--- *** --- INSERT FIGURE 1 HERE --- *** ---

The music compiler and related facilities are based on the assumptions most often encountered in "standard" western music. The form of the language and its default cases have been chosen so that typing in music from a score is as easy as possible. Some of the assumptions which were made are:

1) The fundamental element of the language is a "note".
2) In the default case, a note is determined by specifying a pitch and a duration.
3) In the default case, a pitch is specified by an octave number followed by the note's letter name. The default pitch is derived from the twelve-tone even-tempered scale.
4) Music flows at a tempo which is held constant until explicitly changed.
5) The relative location of the notes is topologically invariant with respect to standard music notation. This means that if you tilt your head ninety degrees to the right, the spatial location of a note with respect to any neighboring note is the same as it would be on a grand staff.

My philosophy has always been to make it as easy as possible for those unfamiliar with computers to accomplish the tasks which they most often desire to perform, but never at the expense of depriving the sophisticated user of the tools s/he may need. Following are a few examples of the tools which have been provided for the sophisticated user of the music compiler:

1) The user may specify an algorithm which will be used to compute the pitch operands to be stored in the note table, thereby allowing compositions to be written in non-standard tunings.
2) Arithmetic and algebraic expressions may be used to compute desired results in the source code.
3) The results of these expressions may be used to specify pitch in three different ways. The result of an expression may be interpreted as a note number (an index into the computable note table of example (1) above), it may be interpreted as the frequency in Hertz, or it may be used directly as an operand for the device. (The last has been found to be particularly useful in writing engineering test routines.)

4) Compile-time random number generation facilities are included.
5) The duration of a note may be specified in any one of four ways, demonstrated here by example:

a) 3c4	quarter note
b) 3c4(3)	quarter note triplet
c) 3c(.5)	half note (may be an expression)
d) 3c(6)	six PLATO output frames (17.5 mS/frame)

6) Execution-time branching has been provided.
7) Complete macro facilities have been provided.

This last point deserves more comment. In many instances, a piece of music contains a recurring form. When this is the case, as in the example of Bach's Prélude in C from Das Wohltemperiertes Klavier (see fig. 2), one desires to specify only the information which changes from one repetition of the pattern to the next. Macros came into existance in computer languages for precisely this reason. Note that in the example, first the body of the macro is defined, setting the form for all following uses. When the macro is called repeatedly, only the changing arguments, which in this case are notes, need be specified. Therefore, each time the macro is called, the user is saved from the agony of having to type the static part of the form again. In addition to the labor-saving quality of macros shown here, we found that macros are extremely important from a compositional standpoint in that they provide a convenient shorthand for specifying a microform. Imagine how simply the pattern for a figured or alberti bass may be represented! (Only the pedal note need be given.) Since macros are expanded by character-string substitution, a minimum of restrictions are associated with their use.

--- *** --- INSERT FIGURE 2 HERE --- *** ---

In addition to the music compiler language which we developed, a number of interactive compositional programs have been written. One allows the user to set up a Schoenberg-style twelve-tone matrix. Compositions are generated by specifying each line as any transposition of the original tone row, its retrograde, inversion, or retrograde-inversion. Another is a simulation of what is known commercially as a "sequencer". Another generates an infinitely repeating loop of random note clusters of the length specified. Still other programs have been written which play pseudo-random notes while generating a display, a kind of multi-media artwork.

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Two of the more important programs are called "gswfcn" and "gswrose". We feel that they are important because they portend what is to come in the future of real-time computer-based composition. They are also some of the earliest examples of interactive art. These programs generate sounds in which the pitches and volumes are determined by abstract mathematical equations which are functions of time. When one uses these "lessons", one specifies a set of equations which will determine the pitch and volume of each voice at each instant in time, and then listens to the sounds the equations generate. One may then modify the equations and listen again. If, at some point, there is a particular set of equations which one likes, one may name them as one does a composition, and store them to be played at a later time. After these equations are stored, they may also be used by any other interactive artist at any of the other one thousand PLATO terminals on the University of Illinois PLATO system as a starting point for her or his composition.

There are a number of remarkable things about this medium. One is simply that it is interactive and evolves with time. Another is that the human being serves more in the role of editor than of creator. The person who specifies the original equations may or may not understand precisely how the computer evaluation of the function will vary with time, but this is unimportant. What is important is that, in the case of all but the simplest (and most boring) functions, s/he has no idea of how the functions will sound. One just listens, and if one likes what one hears, the composition is saved. The last thing which is remarkable about this medium has to do with what some people in the artistic community have begun to refer to as the coming "American Renaissance" (which should, perhaps more properly, be referred to as the "American Naissance"), which is based on a coming-together of art and technology. One of the possibilities that advancing technology makes available to the artist of today is the ability to work in curvilinear (or continuously-variable) form. The coming age of curvilinear form is perhaps observed most easily in architecture. Architects are no longer restricted to designs containing lines, points, and [right] angles. Computational technology has given us the ability to build self-standing curvilinear structures; domes, arches, hanging structures, etc.

In music, one works in different spaces, those of pitch and time. The analog of a straight line or corner in these spaces is quantization. Historically, the number of pitches has been quantized by the notation and instruments available. Timing, once a pulse is established, has also been quantized. The abstraction of mathematics, through the medium of computer-evaluated time-varying functions which describe pitch and amplitude, has given us a performable continuously-variable music notation.

To date we have used only PLATO-IV computer systems to support interactive real-time music synthesis. Conversion to any other computer system would be nearly impossible, due primarily to the vast arsenal of resources which are available on PLATO on which the music subsystem depends. The PLATO-IV system is a large interactive graphics computer system which is used primarily for computer-based education[2,3,4,5,6]. The PLATO system at the Computer-based Education Research Laboratory (CERL) is supported by two Control Data Corporation (CDC) Cyber 73 computers[7] with two million words of Extended Core Storage (ECS)[8], and supports over one thousand PLATO terminals which are located primarily in the United States. Each PLATO terminal[9] has the ability to deliver information to, or receive information from peripheral devices, which include audio disks[10], slide selectors[11], touch panels[12], joysticks, Morse code teaching devices, typewriters (which this paper was typed on), copiers (which the figures were made on), computer systems, floppy disk drives, speech synthesizers, music keyboards, music synthesizers, and many more.

The GSW, which was the first PLATO-compatible music synthesis device, was originally designed for use with the PLATO-IV terminal. With the advent of microprocessor technology, a new generation of PLATO terminals were developed. The new PLATO-V terminals, designed by Jack Stifle, embody all of the features of the PLATO-IV terminals at a lower cost[13], and also afford much greater flexibility. These terminals contain a complete microcomputer system which handles all of the logic and control functions of the terminal. For this reason, the PLATO-V terminal may be thought of as being a computer simulation of a PLATO-IV terminal. PLATO-V terminals are manufactured by Carroll Manufacturing of Champaign, Illinois.

The 8080 microcomputer system in the PLATO-V terminals is capable of executing programs locally. It can also be connected directly to terminal-peripheral devices. These two facts make it possible to accomplish a tremendous number of things related to interactive music synthesis which are not possible with the PLATO-IV terminal. The new functions which this terminal architecture makes possible can be divided into three categories, which are coding, buffering, and local processing.

Some of these enhancements are best clarified by example: Fifteen-bit pitch operands are delivered to the GSW over a data channel with an information bandwidth of twelve hundred bits per second at a rate sufficient to support four voices. If we restrict ourselves to a universe of one hundred twenty eight notes, we can support eight voices with the same data channel, because we can fit two seven-bit note operands in the same space that is currently required for one fifteen-bit pitch operand. The problem then becomes one of coding; How would the note operands be converted to pitch operands? In this case, the answer is that a program may be loaded into the microcomputer of the PLATO-V terminal which performs the proper conversion. In actual practice, a more complex coding scheme may be adopted which will fit even more note operands into the same bandwidth, and also will preserve the ability to play music in alternate tunings.

Buffering techniques may be applied to both output from the central computer to the terminal (forward channel) and input to the central computer from the terminal (reverse channel). An example of reverse channel buffering occurs when using a polyphonic music keyboard connected to a PLATO terminal. Using the keyboard, one may easily play as many as ten notes per second. Assuming that timing information must be sent along with each note played on the music keyboard, as many as four words (sometimes called "keys") will have to be sent to the central PLATO computer for each note. This corresponds to an input rate of forty words per second. Unfortunately, the PLATO system was only designed to handle an average of two and one half words per second per terminal. How can we send forty words per second to a system which will only accept two and one half words per second? The answer is that we can save the information temporarily in the memory of the PLATO-V terminal as it is generated, and send it in to the central PLATO computer at a much lower rate, a technique known as buffering.

An example of local processing may be described in which the same music keyboard input device discussed above and a microcomputer-controlled music synthesizer are attached to the PLATO-V terminal. It may be desirable to have the synthesizer reproduce what is being played on the music keyboard while simultaneously displaying a standard score of the music as it is being performed. To accomplish this, a program can be written and loaded into the PLATO-V terminal which scans the music keyboard to see which keys are being depressed, sends the appropriate operands to the synthesizer, and also scores the music in real-time. All of this processing can be performed locally by the microcomputer contained in the PLATO-V terminal.

The Gooch Cybernetic Synthesizer (GCS) is a device which utilizes all three of these techniques.

The complete GCS hardware system is composed of two completely independent functional subunits which may be used individually if desired. One of the subunits is an intelligent music keyboard. This device contains a microprocessor which scans the music keyboard and alerts the microprocessor in the PLATO-V terminal to any changes in the state of the keyboard. The other subunit is the GCS itself. It is a computer-controlled polyphonic music synthesizer. There are plans to incorporate a microprocessor into the GCS in order to free more time in the PLATO-V terminal microprocessor for generating displays. This may also make it possible to use the synthesizer with other than PLATO-V terminals.

The envelope and waveform of each of the sixteen voices of the GCS are specified via program control. The envelope of a note is actually a function which specifies the instantaneous loudness of a note for the duration of time the note is played. The envelope consists of attack, decay, sustain, and release components (ADSR). During the attack (A) portion of the envelope, which is initiated when a key is depressed, the sound level is increasing. In the decay (D) portion, which immediately follows the attack, the sound level decreases to the sustain (S) level. The sustain portion of the envelope lasts until the key is released. During this time, the volume level of the note remains constant. The release (R) portion of the envelope is the time during which the sound level decreases to zero after the key has been released. In commercially available analog synthesizers, an envelope is designed by specifying four parameters, usually by setting knobs to the length of time that the A, D, and R portions will take, and setting a constant amplitude for the S portion.

In the most commonly used GCS envelope design program, one specifies attack, sustain, and release functions. The most popular way to describe these functions is by drawing graphs of the functions on a PLATO screen with a cursor editor. Since these are functions, and not single linear segments as in the case of analog synthesizers, one may design envelopes of a much greater complexity. Note that the decay portion of the envelope immediately follows the attack portion, so it may also be described by the attack function. The number of envelope generating functions is therefore reduced to three, attack, sustain, and release. In our system, the sustain function is repeated endlessly until the key is released. This makes it easy to generate an electronic tremolo effect. Oddities such as multiple attacks or releases are also easily accomplished.

The description of a key being depressed and released is employed in the above GCS description only as an explanatory paradigm. These functions may well be initiated via the GCS music keyboard, or they may be the result of computer control, or both. A program which exists at the time of this writing allows the user to play along with a computer rendition of a piece.

Ohm's Law of Acoustics states that, to a good approximation, the timbre of a sound is determined by its spectrum[14]. For this reason, the GCS waveform editor allows for drawing the frequency domain description of the waveform. The waveform editor then generates the Fourier transformation of this spectrum, yielding a time domain representation of the spectrum under consideration, which is the corresponding waveform. This waveform is then loaded into the GCS, where it is used to reproduce the desired audio spectrum. Upon hearing the result of this design, the composer is given the choice of storing the waveform in the computer system for later recall, or altering the spectral specifications and repeating the process until reaching the desired timbre.

--- *** --- INSERT FIGURE 3 HERE --- *** ---

At the time of this writing, software evolution is, as always, in progress. Our group has plans to provide facilities for the GCS which are, in each case, analogous to those which now exist for the GSW, and in addition:

1) A facility for generating music source from the music keyboard.
2) A graphical computer music language which is based not on character strings, but on standard music staves.
3) Interactive graphics editors for making edits to music written in the above language.
4) Envelope and waveform libraries. When the user desires that a certain synthetic instrument play a particular part, s/he need only call for it by name. In addition, PLATO has an analog-to-digital conversion input facility, and the parameters which best approximate real instruments will also be available from these libraries.
5) A keyboard practice program in which PLATO displays a score for the student to play. In this particular program, PLATO will not allow the student to progress until the student plays the correct notes.

6) A hard-copy music printing facility. Such a facility has been implemented which provides up to sixteen music staves per page. Sample output from this set of programs is available.
7) There are plans to provide a facility which will automatically assign multiple voices to an instrument in the foreground if fewer than the full sixteen voices are required for a given passage. This will not only improve the definition of a solo instrument, but will also provide a means for generating notes containing temporal evolution of the spectrum, a quality which is usually considered to be limited to synthesis by frequency modulation[15].

--- *** --- INSERT FIGURE 4 HERE --- *** ---

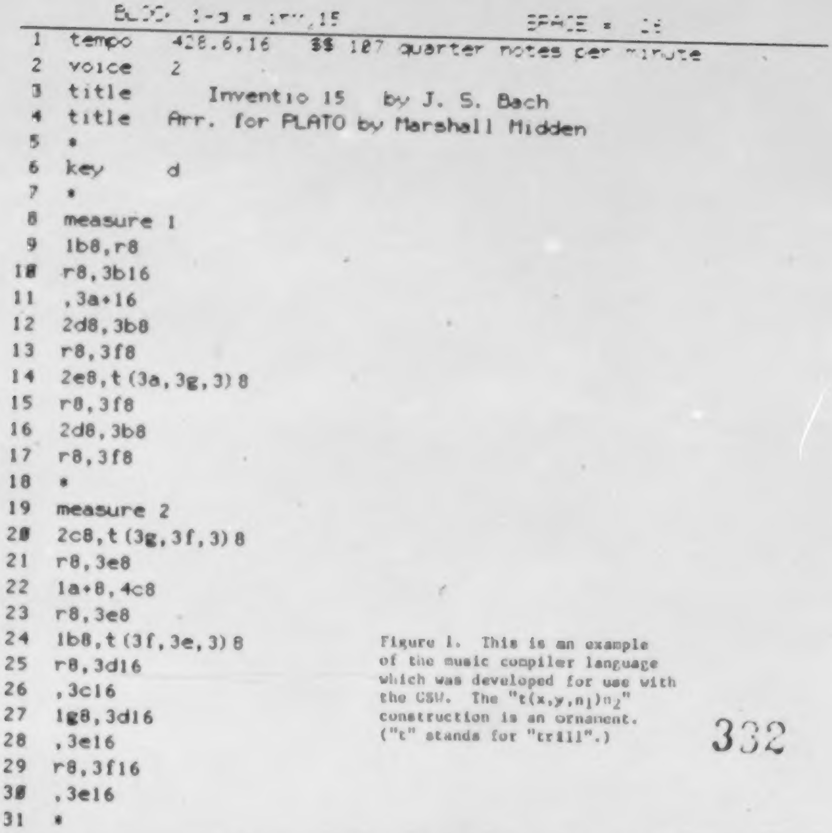
In summary, our goal is to provide tools for music educators to use in the development of instructional materials. Some of the possible instructional materials might include:

1) Music dictation drills involving up to sixteen voices. The variety of drill in which the student must find the difference between the score and that which is heard, as well as a new variety in which the student should actually be able to write on PLATO's music staff the music which has been played. PLATO could grade the dictation for accuracy, define the student's weaknesses, and generate the proper drill to correct the weaknesses.
2) Automatically graded keyboard performances.
3) Envelope and timbre ear-training.
4) Interactive examples or labs in musical acoustics.
5) Composition and theory exercises with immediate feedback.

In closing, I would like to leave you with this thought: Now, with the advent of digital storage techniques, for the first time in the history of art, it is possible to create a work of art which will survive without deterioration, exactly as it was created, for as long as there is rational life.

REFERENCES

1. Fred T. Hofstetter, "Music Dream Machines: New Realities for Computer-based Musical Instruction," *Creative Computing*, 3, No. 2 (1977), 50-54
2. Bruce Sherwood, *The TUTOR Language*, (Minneapolis, Minn.: Control Data Education Company, 1977)
3. D. L. Bitzer and D. Skaperdas, *The Design of an Economically Viable Large Scaled Computer-based Education System*, CERL Report X-5 (Urbana, Ill.: CERL, 1968)
4. J. E. Stifle, *The PLATO IV Architecture*, CERL Report X-20 (Urbana, Ill.: CERL,1971)
5. E. R. Lyman, *A Summary of PLATO Curriculum and Research Materials*, CERL Report X-23 (Urbana, Ill.: CERL, 1972)
6. P. T. Tucker, *A Large Scale Terminal Controller*, CERL Report X-27 (Urbana, Ill.: CERL, 1971)
7. *Control Data Cyber 70 Model 73 Computer System* (Minneapolis, Minn.: Control Data Corp., 1973)
8. *Control Data Cyber 70 Computer System 7030 Extended Core Storage* (Minneapolis, Minn.: Control Data Corp., 1971)
9. J. E. Stifle, *The PLATO IV Student Terminal*, CERL Report X-15 (Urbana, Ill.: CERL, 1977)
10. D. L. Bitzer, R. L. Johnson, and D. Skaperdas, *A Digitally Addressable Random-Access Image Selector and Random-Access Audio System*, CERL Report X-13 (Urbana, Ill.:CERL, 1970)
11. Ibid., p. 8.
12. F. Ebeling, R. S. Goldhor, and R. L. Johnson, "*A Scanned Infrared Light Beam Touch Entry System*," *Digest of Papers - 1972 International Symposium*, Society for Information Display (May 1971).
13. J. E. Stifle, *The PLATO V Terminal*, CERL Report X-50 (Urbana, Ill.: CERL, 1977)
14. M. R. Schroeder, "Models of Hearing," *Proceedings of the Institute of Electrical and Electronics Engineers*, 63, No. 9 (Sept. 1975), p. 1332
15. J. M. Chowning. "The Synthesis of Complex Audio Spectra by Means of Frequency Modulation," *Journal of the Audio Engineering Society*, 21, No. 7 (1973), 526-534

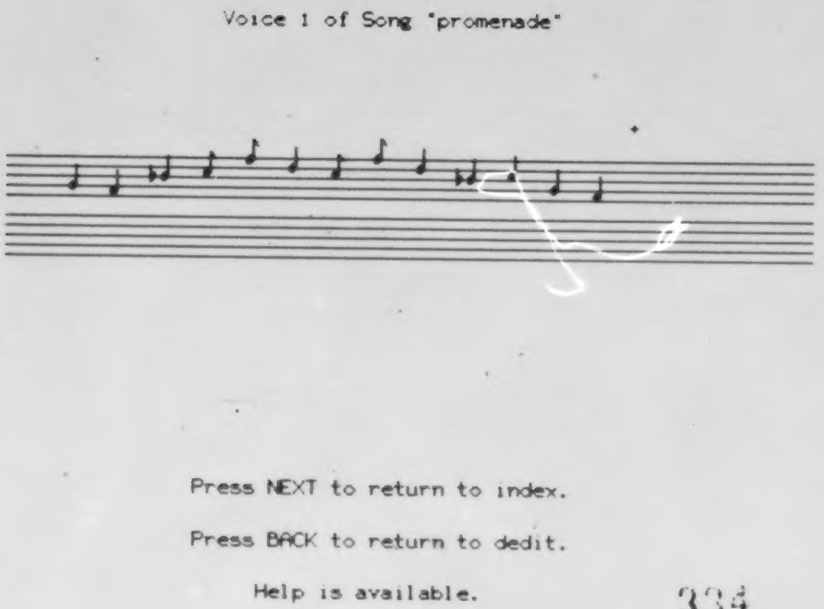


```
     BLOCK 1-a = inv,15                    SPACE = 16
tempo    428.6,16    $$ 107 quarter notes per minute
voice    2
title        Inventio 15    by J. S. Bach
title    Arr. for PLATO by Marshall Midden
*
key      d
*
measure 1
1b8,r8
r8,3b16
,3a+16
2d8,3b8
r8,3f8
2e8,t(3a,3g,3)8
r8,3f8
2d8,3b8
r8,3f8
*
measure 2
2c8,t(3g,3f,3)8
r8,3e8
1a+8,4c8
r8,3e8
1b8,t(3f,3e,3)8
r8,3d16
,3c16
1g8,3d16
,3e16
r8,3f16
,3e16
*
```

Figure 1. This is an example of the music compiler language which was developed for use with the CSW. The "$t(x,y,n_1)n_2$" construction is an ornament. ("t" stands for "trill".)

```
        BLOCK 1-f * prelude 1           SPACE = 220
title   Prelude in C,  by J. S. Bach
tempo   285.7,16     $$ 286 sixteenth notes per minute
voice   3
*
macro   form,A,B,C,D,E   $$ repeats twice per measure
A2,r16,r8
   ,B8d,
   ,    ,C16
   ,    ,D16
   ,B4t,E16
   ,    ,C16
   ,    ,D16
   ,    ,E16
endm
macro   motif,A,B,C,D,E  $$ same for all but last 3 measures
form    A,B,C,D,E
form    A,B,C,D,E
endm
*
measure 1        $$ C
motif   3c,3e,3g,4c,4e
measure 2        $$ Dm7
motif   3c,3d,3a,4d,4f
measure 3        $$ G7
motif   2b,3d,3g,4d,4f
measure 4        $$ C
motif   3c,3e,3g,4c,4e
measure 5        $$ Am
motif   3c,3e,3a,4e,4a
measure 6        $$ D7
motif   3c,3d,3f+,3a,4d
```

Figure 2. This is an example of the use of macros in the CSW music compiler language. Macro "form" is nested inside macro "motif" so that each time "motif" is called, "form" is expanded twice. In this abstract form, each measure requires only one line of typing.



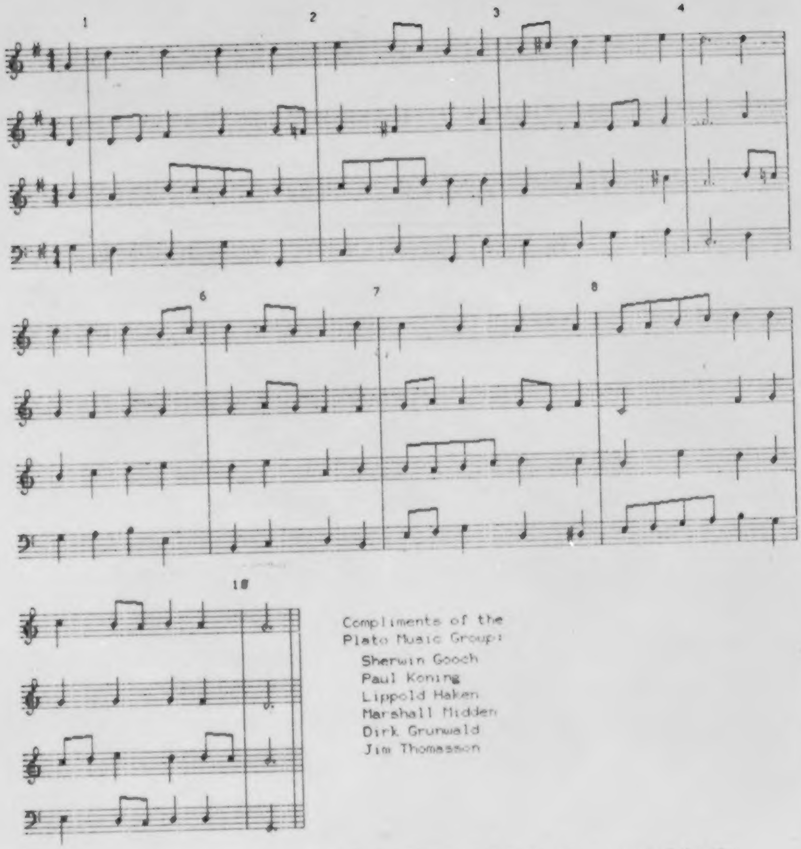
Voice 1 of Song "promenade"

Press NEXT to return to index.

Press BACK to return to dedit.

Help is available.

Figure 3. This is a display generated by a preliminary GCS "staff editor". To use the editor, one locates a position on the grand staff with the joystick-controlled cursor ("+" in the upper right), and then either adds or erases a note at that position.



Compliments of the
Plato Music Group:
Sherwin Gooch
Paul Koning
Lippold Haken
Marshall Midden
Dirk Grunwald
Jim Thomasson

Figure 4. This is a sample of the output which can be generated by the hard-copy facilities. The musical notes used for this listing were played on the intelligent keyboard, then analyzed and sent to the PLATO computer by a preliminary "insert play" program.

Project STRAIGHT- TALK

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I. Introduction

It is an established statistic that black children, who speak a dialect that is different than the prevailing white middle class dialect embodied in the educational establishment, often have difficulties when required to implement social interactions in the dialect with which they are not familiar (see, eg., Northcutt, 1975). A typical educational approach that is taken is to *replace* the so-called nonstandard dialect with the prevailing white middle class dialect. Such an educational approach at least appears to assume that there is something intrinsically wrong with the child's non-standard dialect. There is no question that a pervasive prejudice exists within the confines of the public school system, as well as society at large, against the use of non-standard dialects. But, there are no clear didactic reasons for replacing such dialects with the standard dialect. Presumably it is possible to teach a child the standard dialect as an added-on way of speaking (or writing or reading), and to also teach the child to switch to such a dialect when it is perceived to be socially expedient for him or her to do so. (The subject of the second dialect approach has been discussed, pro and con, extensively, with as yet little conclusive data. See, for example, Baratz & Shuy, 1969; Hall & Turner, 1974; Harber & Bryen, 1976. Most of the discussion so far has focused on the relationship between a non-standard dialect and the comprehension of standard English.)

The CAI system to be described here uses the terms "straight talk" and "everyday talk" to refer, respectively, to standard and non-standard dialects. The name of the system itself is "Project Straight Talk", or, "PST". PST is based on the premise that everyday-talk, although no better or worse than straight-talk, is decidedly less useful than straight-talk in those social situations in which straight-talk is the dominant dialect. These social situations are pervasive, due to the fact that straight-talk represents the norm of linguistic access to many job seeking, information gathering, and educational attainment activities. Straight-talk has a wider ranging survival value than everyday-talk, given the socio-economic structure of current U.S. society. The purpose of PST, then, is to teach various straight-talk production skills, primarily defined in terms of syntactic features.

Since, however, everyday-talk is not to be designated as to be replaced, the method of teaching straight-talk in PST is to teach it as a "second" dialect which is to be related to, compared with, and added on to everyday-talk. This is in some ways analogous to teaching French to an English speaking student by teaching French as a translation of English. A constant focus would be maintained on going from French to English, and from English to French. Points of difference between languages would be directly emphasized, especially where such points involved high frequency aspects of one of the languages, and/or where such points were particularly confusing. The student's English would not be designated as bad, or inconsistent, or lazy. No attempt would be made to get rid of it.

It should be noted that PST does not actually teach talking. The use of "talk" in this paper refers to the linguistic product, rather than to the mode of producing it. However, PST, like other silent teaching materials (such as books), presumably has an effect on the way students talk.

It should also be noted than two types of focus run through this paper. The first focus is on the content of the teaching material included in PST. The second focus is on PST as a CAI system that is independent of the teaching material.

II. PST: Orientation and Content

PST is designed to teach two types of skills. First, it is designed to teach a student to use the concepts of "working" and "not working" to label different types of talk. This system of labelling is in direct opposition to the labelling supported in normal educational efforts. Normally, different language occurrences are designated either as right, or wrong, depending on whether the occurrence fits the conventional patterns that typify the majority culture. Actually such pejorative terms as "bad", "lazy", "meaningless", as well as others, are often used to label non-standard patterns. Thus, a statement such as, "Franny always go to that haunted house -- she just ain't too smart!", would typically be considered poor, or even imcomprehensible, English, or perhaps not even English at all. However, the statement about Franny is quite clear. From the perspective of PST there is nothing bad or poor about the statement.

Clearly, however, such a statement may cause a listener to be critical of the speaker, depending on the social situation in which the statement was made. For example, if the statement were made to a peer who used similar patterns it would "work". If it were made to a white middle class English teacher, it would most likely "not work". PST is intended to teach the student to explicitly label instances of language as working or not working, based on their expediency for a given social situation (e.g., at home, at school, writing a letter to a friend, writing a letter to apply for a job, and so on). The use of the concepts "right" and "wrong" is so ingrained, and, from the point of view of PST, itself wrong, that PST attempts to systematically replace such use with the use of the concepts of working and not working. There is an extended tutorial that interactively defines the terms straight-talk and everyday-talk on the basis of situational utility, and teaches the student to label language instances as "working" or "not working", rather than as "right" or "wrong". A posttest determines the success of this tutorial. If necessary, further practice is given before continuing with the actual syntax teaching to be described below. It should be noted that an understanding of straight-

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talk syntax is not necessary for this tutorial. The notions of working and not working, versus right and wrong, are taught independently of specific straight and everyday talk language conventions.

The second type of skill PST teaches is the ability to recognize and produce various straight-talk grammatical conventions, and to relate them to everyday-talk conventions, where relevant. Straight-talk is presented as an additional way of talking, in particular in certain types of social settings. Training in going from straight-talk to everyday-talk, and from everyday-talk to straight-talk, is the bulk of the course. There are 30 topics which teach various specific straight-talk grammatical conventions (use of negatives, noun/verb agreement, and so on) and relate them to the corresponding everyday-talk conventions, in those cases where they differ.

III. PST: Structure

PST is written in the Coursewriter-III author language. It is composed of three functionally different, but interrelated, components. (1) PST contains a monitor which executes the actual course material. The monitor makes all decisions about what to do next, in terms of the student's response, the student's relevant history of responses, the student's response latency, and the decision criteria included as defaults in the monitor or supplied by the student or the teacher or the author. The monitor also provides a report of the student's activity with PST. The report is displayed at the end of each session. In addition a complete trace of the student's interaction is maintained, and it can also be displayed if desired.

There is a set of commands available to a student as he or she uses PST. These can be entered whenever the system is waiting for a response, and are interpreted as commands rather than as answers to questions. For example, a student can request a brief status report that indicates how he or she is doing on the current topic, with reference to the criteria PST is currently using. The student can ask how much time is left in the current session. Other command options enable the student to skip various parts of the course material, to ask for rules that describe the material currently being taught, to ask for a different topic, and to terminate the session. The PST monitor detects and executes these commands, in some cases subject to various conditions prevailing at the time the commands are entered.

In addition to making presentation decisions, providing status reporting, and providing student command options, the PST monitor also contains routines to allow teachers and others to modify the parameters under which PST operates. Thus, for example, changes can be made to the duration of the session time limit, the response latency criteria, the various criteria used to determine where to go next, the topic list, the makeup list, the type of feedback given to the student, the remediation criteria, as well as to various other values. These changes can be made at any time PST is running, by typing a special command. PST then interactively prompts the user for the various types of changes that can be made, and also provides format and other explanatory information if the user needs it in order to make the changes he or she wants. The changes go into effect as soon as they are entered.

The PST monitor views the subject material as segmented into topics. For each topic there can be a Preview, Tutorial, and Practice phase. The general procedure is to present the Preview in order to determine whether or not to continue with the current topic. If the student has no trouble producing the target answers (according to the default criteria in the monitor, or other criteria specified by the topic author, or the student's teacher, or the student), then PST sequences on to the next topic on the list for the student. If the student has trouble with target answers, PST will suggest skipping the rest of the Preview, or will automatically terminate the Preview and go into the Tutorial phase for the topic. The student may also initiate the skipping of the Preview if he or she wishes to. The criteria for the Preview are structured to enable a student who is having no trouble to get through quickly, and to enable a student who is having trouble to get to the Tutorial quickly. The Tutorial phase for each topic is designed to actually teach the topic. It is followed by the Practice phase which is designed to determine, using the same general presentation format as the Preview, whether the student has mastered the topic. Criteria structuring is similar to the Preview, and skipping is also provided. It should be noted that the PST monitor is independent of the content of the topic material.

(2) The second component of PST is a set of macros that enable authors to write Preview, Tutorial, and Practice phases, using whatever topic content needed. It is not necessary for the author to have any knowledge of computer programming or the Coursewriter language. It is only necessary, using the PST macros, to specify the content (explanations, questions, directions, examples, feedback, etc.) to be presented to the student. The macros are then generated into coding sequences that interface to the monitor. The monitor then runs this material, supplying the various criteria, sequencing, status, and other features outlined above.

Using the macro facility, then, an author (for example, a teacher) can write material to add to the PST material (see (3) below). In addition, an author can write his or her own course that the monitor would execute independently of PST's material. By using the macro facility, along with the facility to change various PST operating parameters, PST can be altered considerably at any time. This can accomplish, for example, the changing of parameters and/or the adding, deleting, or replacing of subject material. This can be done for individual students, groups of students, or all students.

(3) The third component of PST is the content material itself. As mentioned above, there are 30 topics currently written. These 30 topics use, in their interaction with the student, a vocabulary that is intended to support the student when he or she is having problems. The terms "right" and "wrong" are not used to label either language instances or answers the student gives. Answers that match the goal of a given topic are referred to as answers that "work" for that topic, and under those circulstances. The answers that work are the "target" answers the topic is designed to teach.

The specific topics currently included cover such areas as: singular and plural words, verb testers, finding verbs, finding noun phrases, finding verb phrases, modals, verb forms, auxiliaries, finding subjects of noun phrases, finding negative words, using negative words, forms of "be", contractions, and pronouns. Some of these topics have straight-talk target answers, while others require the student to respond in everyday-talk.

IV. Some results of using PST

PST exists in relatively stable condition. Several types of evaluation have been conducted. (1) The first evaluation was the obvious one of determining that the course would operate as intended. This evaluation took a considerable amount of time due to the complexity and size of the course, and was completed successfully. (2) A second evaluation was to determine if the course would teach what it was intended to teach, given that an entering student could not already master the particular content. Fifteen topics were used (all that existed in a completed state at the time of the evaluation), with 30 3rd grade students. Each topic had a Preview, Tutorial, and Practice. If a student who did not meet the Preview criteria could meet the (same level) Practice criteria after taking the Tutorial session, then it was assumed he or she learned what PST was intended to teach. For 11 or the 15 topics, all students who did not meet Preview criteria, and who progressed through the Tutorial, were able to meet Practice criteria. The other four topics were revised but not further tested. (3) For a set of 8 topics which had a concentrated focus on syntactic conventions that differed between everyday-talk and straight-talk, two groups of 8 4th grade students were given different types of instruction. The children were randomly assigned to the two groups. The "second dialect" group took the normal PST instruction. The "single dialect" group took a modified version of PST that did not stress the straight/everyday-talk distinction. For the Practice phase, the single-dialect group made more responses that did not work (average=81.3), than did the second-dialect group (average=52.5). This difference is significant at $p<.01$ ($F(1,14)=11.46$). This is a preliminary evaluation of a "second" dialect approach. (4) All students successfully completed the tutorial sessions that presented the new labels for linguistic instances (that is, "works", "does not work"). This was measured by a linguistic "locus of control" test that was developed, based on the standard locus of control measure, and was given to each student after he or she completed the tutorial. The majority of students scored as "internals". No comparison was made between these scores and actual performance on PST, nor was any pre-measure taken. The locus of control measure was not independent in content from the actual content of the tutorial. This was a particularly interesting result, and, if validated, it could provide, by itself, a justification for PST.

V. Conclusions

PST is a functioning CAI system. It provides the facility to investigate various questions concerning the teaching of straight-talk to children for whom everyday-talk is the predominant dialect. It is a working hypothesis that, as far as it has been evaluated, appears to be a plausible approach to teaching certain aspects of straight-talk syntax to children for whom everyday talk is the standard dialect. The issue of how to teach language production skills is complex, however, and no claims are made on the basis of the above results.

In addition to the complexity of the purely didactic issue (that is, what is the most effective teaching method), it is not easy to decide among the various options for what should be taught. The rationale behind the decision, in PST, to actually teach straight-talk is as follows. It is a fact that straight-talk is preferred in numerous social situations, and that everyday-talk is not. Thus, straight-talk is worth learning, as long as it is depicted as a socially expedient dialect that a user has access to at his or her discretion.

However, it can also be argued that straight-talk is *not* worth learning, since everyday-talk is a legitimate, clear, consistent dialect. The fact that the majority culture uses straight-talk

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does not justify imposing that dialect as a condition for access. Instead, the majority culture should be educated to cease judging everyday-talk as something that is wrong and something that should be changed. As stated above, the choice in PST was that straight-talk is worth learning. It seems to be easier to teach children an add-on dialect than it is to teach adults and children not to be prejudiced.

Although PST teaches straight-talk, there is no implication that this should be a general educational plan. It is simply not possible to make a dogmatic statement about what kind of talk should be taught. The factors that go into making a decision involve political, economic, and cultural considerations that are far more complex than educational considerations. All that can be said is that the content material in PST is intended to represent a hypothesis about only one of the many options.

In addition to the content material, PST is a working system that enables computer-naive authors to generate course material that can subsequently be executed with all the facility outlined above. It is currently being used to develop reading comprehension materials based on research efforts (Nix, in press; Nix & Schwarz, in press) unrelated to syntax production. It could be used to implement other subject matter as well (such as, for example, teaching everyday-talk).

Bibliography

Baratz, J. C., & Shuy, R. (Eds.). *Teaching black children to read.* Washington, D.C.: Center for Applied Linguistics, 1969.

Hall, V. C., & Turner, R. R. The validity of the "Different language explanation" for poor scholastic performance by black students. *Review of Educational Research,* 1974, *44,* 69-82.

Harber, J. R., & Bryen, D. N. Black english and the task of reading. *Review of Educational Research,* 1976, *46,* 387-405.

Nix, D. Linking-mediated syntax in children's sentence comprehension. *Journal of Reading Behavior,* 1978, in press.

Nix, D., & Schwarz, M. Towards a phenomenology of reading comprehension. In R.O. Freedle (Ed.), *Discourse processes: advances in research and theory* (Vol. 2). Hillsdale, N.J.: Ablex,in press.

Northcutt, N. *Adult functional competency: A summary.* Austin, Texas: University of Texas, Division of Extension, 1975.

TOWARD OPTIMAL MANAGEMENT OF CAI: ALLOCATING INSTRUCTIONAL TIME AND MOTIVATING STUDENTS

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In this paper we investigate two questions concerning the optimal management of a CAI system in elementary schools. First, given limited access to the CAI system, what is the best way to allocate available CAI time among the students? And second, how can we motivate students to make the best use of their allocated CAI time even to the extent of voluntarily making up missed sessions or taking extra lessons?

To answer the first question we consider several objectives that might be reached through appropriate time allocations. Examples include maximizing the students' mean grade placement without increasing the variance and maximizing the number of students who make a particular gain. Using an operations research approach, we suggest time-allocation strategies to optimize the chance of reaching each objective. Finally we use learning curves estimated from observed data and a computer simulation of each strategy to predict the outcomes of various allocation strategies.

Our simulation models indicated, somewhat surprisingly, that given reasonable assumptions concerning the ways time can be allocated during a normal school day, different time-allocation stragegies make very little difference in overall results. What does make a difference, however, is the total amount of CAI time used by students. For example, the school grade-placement average can be increased as much by increasing total CAI time by ten percent as by any allocation stragegy we tested.

These results led us then to the second question of how we can motivate students to use more CAI time. Traditional measures of academic progress such as percentage scores and grade equivalents are not good motivators when used in connection with CAI curriculums and remedial students. Percentage scores are not appropriate because most highly individualized CAI curriculums adjust problem difficulty to keep error rates fairly constant. Additionally, for remedial students it is not usually desirable to reveal true grade placement levels. To avoid these problems and to take advantage of natural social motivations, we devised a CAI contest in which points are accumulated according to the number of correct responses given by individual team members. The number of correct responses provides a good measure of student progress and gives the contest a desirable feature not found in most academic games: the contribution of an individual depends not so much on academic ability as on a willingness to spend time working productively for the team.

Allocating Available CAI Time

Progress Objectives and Time Allocation Strategies

In a school with CAI terminals there must be some way of allocating the available terminal time among students. Usually there are some constraints imposed on this allocation by features of the CAI system and by features of the school itself. For example, in our simulations we have assumed that every student is scheduled for one 10-minute lesson per day and that no one receives more than one extra lesson per day. In this way we give every student at least some minimum opportunity to benefit from the CAI program, but we don't schedule anyone for an excessive amount of time in any one day. We have also assumed that five hours of a school day are available for regularly scheduled CAI lessons and one hour is available for extra or make-up lessons.

In addition to constraints, however, any allocation of time among students must use some objective--either implicitly or explicitly. We will try to give a sense of the variety of plausible achievement objectives and the range of time-allocation strategies they imply by discussing six different objectives and the corresponding allocation strategies that seem intuitively to be appropriate. We will see that some of the objectives that seem quite reasonable require allocation strategies that are not particularly appealing. Table 1 summarizes the objectives and strategies. We assume that when students spend time in CAI, they make progress, but some at faster rates than others.

Objective 1: Maximize mean grade placement. Maximizing the mean grade placement appears to be an obvious and reasonable objective. This objective implies that we allocate the available time among students in such a way that the average grade placement of participating students is as high as possible at the end of the school year. Since fast learners by definition make more progress per unit of time than slow learners, the time allocation strategy that optimizes this goal is simply giving all the time to the fastest learners. This strategy has the obvious fault that it does not allow the slow learners any benefit from CAI.

Objective 2: Minimize variance in grade placement. If our objective is to minimize the variance in grade placement, the appropriate time allocation strategy is to give most of the time to the slowest learners and almost none at all to the fast learners. Specifically, the fast learners receive only enough time to keep up with the slowest learners. Under this strategy we hold back the very learners who seem to benefit most from CAI, and, of course, we have a smaller mean grade placement than we would achieve under the first strategy.

Objective 3: Maximize mean grade placement subject to the constraint of not increasing variance. A third objective which is a compromise between Objectives 1 and 2 is to maximize mean grade placement while not allowing the variance to become greater than it would have been without CAI. To optimize this objective slow learners must be given more time than fast learners, but the differences in amount of time for the two groups would not be as great as in Objective 2.

Atkinson (1972) considered all three of these objectives and recommended Objective 3 as the most desirable and equitable goal for allocating instructional time. Because this objective might not meet the needs of every school environment and for purposes of comparison, we consider several other possible objectives.

Objective 4: Maximize the number of students at or above grade level. Maximizing the number of students at or above grade level holds the same kind of intuitive appeal as maximizing mean grade placement. When we maximize the number of students at or above grade level, we have specified an acceptable achievement level for each student and are not interested in any group averages. We are saying in effect that one student reaching grade level is better than any number of students who almost, but don't quite, reach grade level, and that a student who far surpasses grade level is of no more benefit to optimizing the objective than a student who just barely reaches grade level. To optimize this objective most of the time should be given to students who can just barely reach grade level. No time at all should be given to students who are already above grade level or who would take a very long time to reach grade level. We would rank order the students according to the amount of time they need to reach grade level, and then allocate that amount of time to students beginning with the student who needs the least amount of time and continuing until all of the time has been allocated.

Objective 5: Maximize the number of students who gain one year. For many students, particularly the educationally disadvantaged students, who are presently the primary users of CAI programs, an objective such as Objective 4 is unreasonably high. Often these students are so far below their chronological grade level that to reach that grade level in one year is unrealistic. A more appropriate objective then might be to maximize the number of students who achieve a specified gain such as one year. Objective 5 could also be thought of as an intermediate objective to be used for a year or two before adopting Objective 4. The strategy for optimizing Objective 5 is similar to the strategy for optimizing Objective 4, the only difference being in the acceptable performance level for each student.

Objective 6: Equal time to all students. An egalitarian principle might imply that equal amounts of CAI time should be given to all students without regard to individual learning characteristics. This objective would of course be optimized by a uniform distribution of time across all students.

Computer Simulation of Different Allocation Strategies

In this section we use a computer model of student progress and simulate the effects on progress of some of the allocation strategies we have discussed. There are a number of mathematical techniques that can often be used to find optimal solutions (e.g., Cooper & Steinberg, 1970), but these techniques are sometimes difficult or impossible to apply in practice. Therefore, our first steps were to simulate the strategies that would result in approximately the highest and lowest possible values for final mean grade placement. As we will see, the differences between these strategies are not very great.

Prediction equation. In order to simulate the effects of different time allocation strategies we need a model of student progress that predicts grade placement as a function of time spent in CAI. We have previously discussed and statistically compared several such models (Malone, Suppes, Macken, Zanotti, & Kanerva, 1977). For our present purposes we select the model

$$GP(t) = bt^{.45} + c \qquad (1)$$

where $GP(t)$ is the predicted grade placement for a student after t minutes of computer lessons and b and c are learning parameters that are estimated individually for that student. This model had a standard error of fit of .098 for the mathematics curriculum that we use in our simulations here, and a standard error of .072 for the reading curriculum. We found that the model

$$GP(t) = bt^{k} + c \qquad (2)$$

where b, c, and k are all estimated individually gave slightly lower standard errors of .073 for mathematics and .064 for reading, but we chose not to use this second model for our simulation because of its greater computational complexity.

We estimated the parameters of Model 1 for 2,443 elementary-school students in the Fort Worth Independent School District who were taking a CAI mathematics curriculum developed by Computer Curriculum Corporation. We made these estimates by fitting curves to 15 to 25 data points for each student. The points were approximately evenly spaced throughout the year and consisted of the student's CAI grade placement and corresponding accumulated CAI time. A more detailed description of the students, equipment, curriculum, and data points is given by Malone et al. (1977).

Simulation. Using the individual prediction equations we simulated each student's progress under different time allocation strategies. We allocated time according to a particular strategy, predicted the grade placements that would result after the allocated time was spent, and then allocated more time based on the new grade placements. We repeated this process for 4-week intervals until a whole year had been simulated.

Table 2 gives monthly summaries of the results of such a simulation. Time was allocated according to a uniform distribution with each student receiving six lessons per week. We can think of this as each student receiving one regular lesson per day with extra time being divided evenly so that each student also receives one extra lesson per week. By the end of the year the mean grade placement for all CAI students had risen from 3.1 to 4.9. The standard deviation of the final grade placement was 1.3 years. Eighty-seven percent (2,134) of the students had reached an arbitrarily designated goal of 1.2 grade years gain.

To examine the magnitude of the effects different allocation strategies have on end-of-year grade placement, we compared the results of the uniform strategy to the results given by the two strategies that would cause the highest and lowest mean final grade placements. We again assume that 5 hours of a school day are devoted to regular CAI sessions during which time each student receives one session; we allow 1 hour per day for extra sessions, and the strategies apply only to this hour. The lowest possible mean final grade placement would be obtained if all of the extra sessions were given to the slowest learners, and the highest mean would be reached if all extra sessions were given to the fastest students.

If we knew precisely the learning curve for each student, we could pick out exactly which students would be the fastest and slowest learners in each month. But our results, reported by Malone et al. (1977), indicate that there is substantial error in estimating the learning curves until near the end of the year. We therefore make the simplifying assumpion that the slowest learners are those who have made the least progress since the beginning of the year, and the fastest learners are those who have made the most progress.

The mean final grade placement, the standard deviation and the percent and number of students who gain at least 1.2 years as a result of each of the three strategies are shown in Table 3. The surprising result is that the mean final grade placments differ by at most .1 grade year and the standard deviations by at most .3 grade years.

These differences do not seem to be significant either practically or statistically. As noted above, when equation 1 is used to predict grade placement, the standard error of fit is .098 grade years, which makes a treatment difference of .1 grade years statistically insignificant.

In terms of practical significance the simplest allocation strategy--dividing lessons evenly among all students--gives results which are almost as good as the strategy that gives all the extra time to the fastest learners. The mean final grade placements are the same and the standard deviations differ by only .1 grade year. What our results seem to indicate is that at least in situations where only 1/6 of the total time is available for extra lessons, it is not not worth the cost to select particular groups of students to use the extra time. It is evidently more important to simply make sure the terminals are being used during the extra time regardless of which students are using them.

Furthermore, if we distribute extra time uniformly and increase the amount of extra time available by 10 percent, we find that each addition of 10 percent more time for extra sesions adds approximately 0.1 grade year to the final-grade-placement average. These results are shown in Table 4. Again the evidence seems to indicate the importance to student progress of providing as much time for extra sessions as possible and of insuring that the extra time is always used.

Motivating Students to Use Available CAI Time

Based on these results we considered various ways of encouraging students to spend more time taking CAI sessions. Any alternatives which involved teacher or proctor responsibility seemed undesirable because of the amount of extra work that would be created by the extra scheduling. The best alternative seemed to be to motivate the students themselves to want to spend extra time, and that led us to the idea of implementing computer contests.

We have completed some pilot work in the Houston Independent School District concerning the motivational effects of computer contests played in teams. The individualized nature of Computer Curriculum Corporation's CAI courses made it possible to devise a contest in which winning depended more on each team member's willingness to spend time in CAI than on his or her individual ability or achievement level. The team score was based on the total number of correct answers accumulated by the team members. Because the computer adjusts exercises to individual ability levels, the probability of a correct response is approximately equal across students. Thus, while we expected an individual's contribution to the team score to be directly related to the amount of time he or she spent taking CAI lessons, students were not rewarded for spending time unproductively.

Team scores were computed each week with correct items contributing one point each; items from regularly scheduled sessions, make-up sessions, and extra sessions were all included equally. Scores were adjusted for team size, and weekly winners were announced. The winning team received a small trophy which was held for a week and then presented to the next winner. At the end of the contest period, grand prizes were given to members of the team with the greatest number of total points. In our pilot study, the grand prizes were large "Computer Superstar" decals that could be ironed onto a T-shirt.

Our pilot study indicated that the contests were effective both in generating student enthusiasm and in increasing CAI time and CAI grade-placement gain. The pilot study results also indicated that the contests were more effective when teams consisted of students in the same classroom rather than students who happened to be scheduled in the computer lab at the same time. A more detailed discussion of the data analysis and the results will appear in a later publication.

One issue that is sometimes raised about these contests is whether or not they encourage undesirable competition. First, it is important to realize that the cooperation between students on the same team may be even more important than the competition between students on different teams. In fact, because of the automatic adjustment of problem difficulty to student ability, these contests may be one of the very few situations where low ability students can contribute on an equal basis to an academic goal that is important to both them and their peers. There could also be non-competitive versions of these contests (e.g., each team working independently for separate rewards), and we think these alternatives are worth investigating.

Conclusion

In the first part of this paper we showed how ideas of optimizing specific objectives could be applied to the problem of allocating CAI time among students. Then using computer simulation methodology we found that, for our courses and students, simply increasing the total amount of CAI time used could probably improve overall student progress more than any practical allocation strategy. In other words, administrative time in a CAI program may be better spent trying to increase the total amount of time a CAI system is used rather than trying to allocate a small number of extra lessons to a few students.

In the second part of the paper we briefly described one way of trying to increase the total amount of time a CAI system is used. Rather than require the burdensome administrative task of scheduling students for additional lessons, we devised a contest to motivate students themselves to miss fewer lessons and voluntarily take extra lessons. The CAI program's automatic adjustment of difficulty level allows for a unique kind of academic contest where students of different ability levels have an equal chance of success. The use of the contests appeared to be successful in meeting our objectives for system use as well as in generating a great deal of enthusiasm on the part of students.

We feel that the three main topics discussed here--the explicit consideration of overall objectives, the use of computer simulation methodology in time allocation, and the use of motivational games in CAI--are all potentially applicable in a wide range of CAI settings. Now that many of the basic problems of implementing CAI have been solved, it is time to devote some of our attention to broader issues of instructional design. We hope that our work described here provides at least a start in that direction.

References

Atkinson, R. C. Ingredients for a theory of instruction. American Psychologist, 1972, 27, 921-931.

Cooper, L., & Steinberg, D. Introduction to Methods of Optimization. Philadelphia: W. B. Saunders Co., 1970.

Malone, T. W., Suppes, P., Macken, E., Zanotti. M., & Kanerva, L., *Projecting student trajectories in a computer-assisted instruction curriculum*. Manuscript submitted for publication, 1977.

Table 1

Alternative Objectives and Strategies for Allocating CAI Lesson Time Among Students

Objective	Strategy
1. Maximize mean grade placement.	Give most time to fastest learners.
2. Minimize variance.	Give almost all time to slowest learners.
3. Maximize mean grade placement subject to not increasing variance.	Give more time to slower learners but not as much as 2.
4. Maximize number of students at or above grade level.	Give most time to students who can barely reach grade level; give no time to students who are already above grade level or who would take a very long time to reach grade level.
5. Maximize number of students who gain at least one year or some other goal expressed in amount of gain.	Give most time to students who can just barely reach goal; give no time to students who have already reached the goal or who would take a very long time to reach it.
6. Equal time to all students.	Uniform assignment of time.

Table 2

Simulation of Model 6, Equal Time to All Students,
for 2443 Ft. Worth Students in Grades 3-6:
All Students Receive 5 Regular and 1 Extra
Mathematics Sessions per week
Progress is Predicted by the Equation,
$GP(t) = bt^{.45} + c$

Week	Mean grade placement	Standard deviation	Number and percent of Students who gain at least 1.2 years	
4	3.12	.83	25	(1%)
8	3.47	.91	447	(18%)
12	3.76	.98	1050	(43%)
16	4.00	1.05	1442	(59%)
20	4.22	1.11	1730	(71%)
24	4.41	1.17	1888	(77%)
28	4.59	1.22	2002	(82%)
32	4.76	1.27	2072	(85%)
36	4.91	1.31	2134	(87%)

Table 3

Simulation of Student Progress in Mathematics
Resulting From Three Different Time Allocation Models;
N = 2443

Allocation Model	Mean grade placement	Standard deviation	Number and percent of Students who gain at least 1.2 years
1. Maximize mean grade placement	4.9	1.5	2048 (83%)
6. Equal time to all students	4.9	1.3	2134 (87%)
Lower bound: minimize mean grade placement by giving all extra lessons to slowest learners	4.8	1.2	2247 (92%)

Table 4

Simulation of Student Progress in Mathematics
Resulting from Increasing Time Available for Extra Sessions
and Allocating Extra Time by Model 6,
Equal Time for All Students;
N = 2443

Percent of Increase in Extra Time	Mean grade placement	Standard deviation	Number and Percent of students who gain at least 1.2 years	
0	4.7	1.2	2033	(83%)
10	4.8	1.3	2089	(86%)
20	4.9	1.3	2134	(87%)
50	5.2	1.4	2195	(90%)
100	5.6	1.5	2254	(92%)

CAI and Developmental Education

-University College, University of Cincinnati

submitted by Rick Anderson
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equipment: 3270's and Telrays

language - CW III, version 3

I prefatory remarks - This project paper from the CAI Lab of the University College, University of Cincinnati, is intended to accomplish three tasks at the national conference in Dallas and in the Conference Proceedings: 1) aiding other CAI-users by showing our struggles and achievements, particularly in the area of justification; 2) furthering contacts with other people who have CAI-courses to exchange; and, perhaps most importantly, 3) providing a general benevolent catharsis, telling our pride of accomplishment, venting our frustrations!

II overview - CAI has been at U.C. only since 1970. The writer was engaged in the initial implementation, in the area of German, and learned that good course material isn't sufficient. In order to succeed for the duration, a CAI-project needs to have a broad base not only of faculty support, but also actual faculty involvement.

The second major U.C. CAI-project has turned out to be more lasting. At present the most intensive use of CAI on campus, the CAI Lab is an administrational part of the University College Developmental Education (DE) Center's effort to serve students who for a variety of reasons lack mastery of certain college-level skills. Two sets of CAI-courses focus on the "meat and potatoes" of any DE curriculum, basic mathematics and English.

Open sixty hours a week, the CAI Lab last year serviced a total of about 300 students a quarter in these courses.

CAI Lab Director Mike McSwigan of the University College Department of Mathematics runs the "CAI-Math Lab," which offers three choices to math students. Those who are taking the DE course *Basic Math* can enroll in a CAI-course for one-hour credit. There they will receive a thorough review of fundamentals as a supplementary to the classroom course. Second, students can take entirely by computer the standard three-credit University College course, *Introduction to General Statistics*. As a benefit of CAI, they can work on it as their schedules dictate, and their movement through the course is individualized. Increasing numbers of students from other colleges have been enrolling. Third, a number of students enroll in a variety of CAI-precalculus courses, voluntarily or at the behest of their instructor. These constitute "brush-up" tutorials for the students, some of whom come from other colleges. No academic credit is involved. And, finally, student proctors in the CAI Lab offer some limited "human" tutoring services to students.

The writer of this paper administers the English program of the CAI Lab. I have developed two CAI-courses for it, complete with pretest, programmed drills and posttest: *irreg*, on the 125 irregular verbs (e.g., "to do," a chronic problem for dialect speakers); and *spell*, on community college freshmen's common spelling errors. The English CAI-program has been run in conjunction with the DE Center's Writing Lab. The student who enrolls in the DE course *English for Effective Communication* has class four times a week. Two of these are spent in the Writing Lab, where tutors guide him or her through comprehensive programmed grammar instruction and the instructor is freed to tutor composition individually. The students then are referred to the CAI Lab for CAI-English at certain pre-determined points in the Writing Lab instruction. With this working arrangement now fairly well established after two years, we are beginning to offer these CAI-courses to other University College English students.

The CAI-Lab serves as resource to faculty members wanting to develop or use CAI-units. For example, one professor in the College of Education is running this year a CAI-seminar for graduate students and teachers-in-training. He is using our facility and personnel as part of his course. And during the last academic year the Lab had a graduate assistant who, among other tasks, entered English programs onto the system.

Understandably enough, this type of large university student service requires a great deal of instructional and faculty development. For instance, college CAI-English is relatively undeveloped and unaccepted, compared to mathematics and the other scientific disciplines. Thus, we could borrow CAI-math courses from Kansas City and our colleagues at Akron, while there exists a shortage of readily and inexpensively available CAI-English courses, even nationally. We have had painstakingly to develop our own and to set up exchanges with a few other institutions, like Fox Valley in Wisconsin and Rhode Island Junior College.

Two areas in particular have caused problems and concern. Financial difficulties are on-going and inextricably connected with the current dilemma of higher education. U.C. has just converted from the last municipal university in the country to a state institution, for that very reason. (The irony of it is that it doesn't seem to have helped!) A second problem, quite common to CAI-users, is justification. Since CAI-English at U.C. has at first been a subordinated part of the whole DE program, accountability to more than one administrator has been the case. Too hasty judgements from too narrow a perspective occurred, primarily from a lack of experience, time and openness on the part of a secondary administrator. These doubts concerning CAI-English were passed on orally. However, several careful and thorough written reports to all faculty and administrators (one of which is summarized below) negated the unsalutary effects. The hard data in these reports on student evaluation, progress and usage also gave the computer center helpful systems information. The latest sign of our growing support is that the first issue of a University College newsletter on instructional development has featured the CAI Lab with a cover-photo and article.

Pedagogically exciting student service and instructional and faculty development--these three essential elements define the efforts of the CAI Lab as part of the DE Center, the University College and the University of Cincinnati, as a whole.

III report - A comprehensive report on irreg was produced at the end of the academic year 1976-77. It was based on student evaluations and usage in the winter quarter. Approximately 100 students took the course; 55 returned the evaluation forms.

STUDENT EVALUATIONS - Most students found appropriate:

1. the sentences and vocabulary
2. the course content
3. the presentation method
4. the course tests

They would like to take more CAI courses on similar topics and would recommend irreg to their friends. Seventy-nine percent of the student evaluated never, or at most once, had difficulty operating the terminal. Eighty-two percent never, or at most once, had to wait a long time for responses from the computer. Seventy-five percent never, or at most once, were interrupted at the terminal by computer breakdowns ("down time"). Seventy percent found the lab proctors very helpful in terminal registration and problems.

ANALYSIS OF STUDENT EVALUATIONS - Except for two questions, the findings were significant to .001, using chi-square analysis. The language of the invalid questions were altered; technical terms confused the students. A significant minority of the students evaluated the course as "easy." They will be advised in the future to take the posttest immediately, as is possible in the course, and avoid the drills. If this suggestion doesn't work, the course posttest will be made more difficult.

SYSTEM PERFORMANCE (based on the CAI Lab log) - *Irreg* was supposed to be available ("on line") to EEC students a total of 420 hours. Thirty-nine hours (9%) of that total were interrupted by system problems, i.e., the computer was down or some other sort of technical problem interrupted the instruction.

ANALYSIS OF SYSTEM PERFORMANCE - Two factors were present that contributed significantly to down-time. One was technical problem with telephone connections and was corrected. The CAI Lab log showed a marked decrease in down-time after the repair date. The other was a long-standing strain on the central computer (an Amdahl 470/V6, equivalent to an IBM 370/168) at certain busy hours of the afternoon, due to time-sharing. While this problem has been more difficult to correct, it was helpful to note that the hasty criticism mentioned above arose partly because that particular administrator was only around at those hours!

The evaluation questionnaire and the complete version of the report discussed are available to all who are interested. Combined with the comprehensive log the CAI Lab proctors maintain, they provided a strong base for justification of the facility.

Evaluation of a Three Year Health Sciences PLATO IV Computer-Based Education Project

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Introduction

During the period (July, 1973 - July, 1976), efforts were undertaken at the School of Basic Medical Sciences (SBMS), Urbana-Champaign (UC), University of Illinois College of Medicine to develop a computer-based curriculum in the basic medical sciences by using the PLATO IV computer system. These development efforts were supported, in part, by a Department of Health, Education and Welfare, Bureau of Health Manpower contract (No. 1-PE-34-68). The contract, entitled "PLATO IV Applications in the Basic Medical Science," was for three years. Pursuant to this contract, a comprehensive evaluation of the Project was conducted. The Office of Curriculum and Evaluation (OCE), School of Basic Medical Sciences-UC was contracted in July of 1975 to develop and conduct this evaluation. The goal of this paper is to present the significant findings of the comprehensive (112 pages) evaluation conducted by OCE.

Background

The School of Basic Medical Sciences at Urbana-Champaign has been involved in an innovative educational approach to the preclinical year(s) of medical education. When SBMS-UC opened in the Fall of 1971, basic science faculty and local practicing physicians prepared a basic medical sciences curriculum to provide medical students with the skills and knowledge necessary to allow entry into a clinical training program after 10 months of study. The curriculum contained 12 basic medical science disciplines and was organized into a five volume document. The curriculum contained over 400 self-instructional units and incorporated over 4,000 specific learning objectives. Each curriculum unit included all necessary components to allow the student to proceed at his/her own rate of progress and in a manner consistent with his/her own learning style.

In addition, to demonstrate the relevance of basic science to clinical medicine, each of the 400 learning units was related to one of 10 clinical problems or diseases. While studying the learning units, each student is provided multiple opportunities to interact with local practicing physicians and their patients. These interactions serve to facilitate the correlation of the basic science content and clinical problems or diseases. The specific patient problem is used as the entry point into interdisciplinary principles of basic science germane to the understanding of medicine as a whole.

The SBMS-UC program relies heavily on its 25 full-time-equivalent (FTE) basic science faculty members to assist students in acquiring knowledge/skills in the 12 basic science disciplines. Each faculty member carries joint responsibilities with the medical school and with a corresponding appropriate department on the Urbana-Champaign campus. The full-time SBMS-UC faculty are responsible primarily for preparing and revising the curriculum document. They also present lectures, laboratory exercises, and demonstrations for the students. Faculty also advise medical students throughout the year.

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Student progress in the SBMS-UC program is assessed by three methods: (1) self-testing by the students via pre- and post-test questions (Levels I and II) in each learning unit; (2) objective, cognitive assessment with a comprehensive diagnostic examination (Level III) given after each of the curriculum divisions (clinical problems); and (3) an oral examination, given by a physician, (Level IV) in which the students' ability to relate the basic sciences to each clinical problem is tested.

An interesting feature of the Level III assessment is that it is administered to students via PLATO IV. Since 1972, computers have been used by the School to implement the Level III method. This medium was and is currently being used to complement the self-paced, individually-guided educational program.

SBMS-UC PLATO IV Proposal

To complement and add support to the existing SBMS-UC educational program, administrators at the School, in 1973, sought and received monies from HEW to develop and implement the Computer-Based Education Project (CBEP). Some of the more important features of the initial proposal and ensuing three year HEW contract were:

1. A core curriculum of approximately 300 PLATO IV computer units was to be developed.
2. The materials developed by the CBEP were to cover the same general scope as the SBMS-UC curriculum.
3. Developed computer lessons were to include learning objectives, self-testing, and evaluation devises.
4. A modular format was to be developed that would allow for multiple entry and exit points within each module that would permit students with different training levels equal access to the same materials.
5. Computer lessons were to be developed to meet the specific needs of disadvantaged students.
6. The computer lessons were to be designed so they could be exportable to other institutions without major changes.

The Project staff was to be primarily full-time, in recognition of the intensive effort anticipated for the adaptation of the new teaching system to health sciences.

> "The composition of the staff was to include basic scientists with advanced degrees who were to work closely with physician contributors to maintain a clinical orientatior in the developed lessons.

Each basic scientist was expected to learn enough of the fundamentals of the programming language to be fully conversant with the system's capabilities and limitations. In practice this would mean that the basic scientists "content specialists" would program a portion of their own materials. In order to use their time more efficiently, they were to be assisted by programmers for the bulk of the actual "encoding" tasks and by programming consultants to maintain a sophisticated level of machine function. While they would not have regular conventional teaching duties, the content specialists were to be closely linked with the regular SBMS-UC campus teaching faculty."[1]

The Health Sciences Network

It is important to note that during the first year of CBEP an additional task of enormous scope was undertaken by the Project. This task was the attempted development of a national "authoring and use" PLATO health science network.

The rationale and definition of this network are stated by the Projects' director as

> ". . . it was already clear that the needs for a large body of lesson material could not be completely handled at a single institution, even with the assistance of the special faculty group and support staff that was funded under contract. It also seemed evident that interinstitutional participation would lead to a broader perspective of needs and more approaches to fulfilling them. A more diverse cadre of students could react to the educational material created. These were all seen as distinct advantages. It was recognized that wider participation might well lead to more diffuseness of educational objectives, by attempting to tailor the lessons to the differently perceived needs of varying institutions. Also, there would be additional costs in terms of training authors at remote sites, communication costs between outlying institutions and Urbana, Illinois, and, not the least important, the considerable overhead in faculty time in planning and administering such an informal consortium. However, it was felt that the advantages clearly outweighted the problems, and beginning in 1974, PLATO terminals were loaned by the University of Illinois to a number of other medical schools that agreed to undertake the authoring of lessons and to give their students access to the developing library of health sciences lessons. Outside participants paid a share of the PLATO service costs as well as the actual communications costs. Since 1974, seven institutions have participated in this effort in an organized fashion.[2]

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[1] Hody, G. L., Levy, A. H. "PLATO IV Applications in the Basic Medical Sciences - Part I, May 1976, pp.

[2] Levy, A. H., "An Interim Report, Computer-Based Education: Processes and Potentials, July 1976, p. 4.

Methodology

The evaluation was designed to assess the progress of the Project relative to the goals outlined in the contract (summative evaluation), provide feedback to the Project and School personnel, as well as to the funding agent (summative and formative evaluation), and portray the Project as it had evolved since its inception. Secondary to these goals, it was the desire of the evaluators to provide information to a diverse audience interested in innovation in medical education and development of computer-assisted instruction.

The techniques of responsive evaluation and portrayal (Stake, 1972, 1974) were used to portray the Project as it had evolved during its existence. The methods of Stufflebeam (1971) -- CIPP -- and Provus (1972) -- Discrepancy Evaluation -- were employed to assess the Project's accomplishments, to provide information for decision-making to the funding agent and School personnel, and to examine the contributions of the Project to computer-assisted instruction and innovation in medical education. Information from the portrayal was also useful in evaluating all aspects of the Project's functioning. The portrayal also served to provide formative feedback to Project personnel.

As a first step in the evaluation, the objectives of the contract were outlined. Three major objectives were identified: development of course teaching material, implementation of the course material, and effectiveness of the course materials. These objectives were then delineated into small (sub) objectives which could be measured more easily. For each (sub) objective, the evaluation questions were identified, data sources specified, and analysis strategies outlined. Data were gathered from varied sources. Interviews were conducted with teaching faculty at SBMS-UC, allied health professionals, the Dean of the School, past and present Project directors, and Project authors. Opinions about the courseware were also obtained from medical students and site directors via questionnaire.

In order to evaluate quantitatively lesson effectiveness, lesson usage and performance data were examined. In the first group of analyses, lesson usage and performance of Urbana students on relevant portions of Urbana diagnostic examinations (Level IIIs) were analyzed. Means and standard deviations were calculated. A *t*-test was used to examine performance of "users" and "nonusers." Because the correlation between the discriminant function and performance was essentially zero, *t*-tests for the difference between two means were favored over an analysis of covariance with the discriminant function as a covariate. The discriminant function is a weighted composite of incoming ability measures such as MCAT scores and undergraduate grade-point average. It has been used by the College of Medicine in the admissions process and has been shown to correlate most highly with performance in the first year of medical school.

In the second major analysis, lesson usage and performance on appropriate segments of a college-constructed certifying examination were analyzed for students enrolled at Urbana and Chicago. Since a significant correlation was observed between the discriminant function and performance on the examination, a two-way analysis of covariance with the discriminant function as the covariate was used. In this analysis, performance on an appropriate segment of the June College Certifying Exam was the dependent variable; usage of lessons and educational program membership were the independent variables.

Analysis of Urbana Student PLATO Lesson Usage and Examination Performance

PLATO lessons were grouped according to their applicability to content tested in specific sections of the SBMS-UC diagnostic examinations (Level IIIs). The groupings were determined by the assignment of lessons to basic science curriculum units and by the assignment of these units to clinical problems within the SBMS-UC curriculum. Each Level III examination tests a student's knowledge of the basic sciences as specified by curriculum units within a curriculum module called a clinical problem. Judgments about the association of PLATO lessons with curriculum units were made by Project authors. The mapping of lessons to units was provided to students in an on-line catalogue at the beginning of the academic year.

Since not all clinical problems had associated with them a moderate number of basic science lessons, it was decided that only select portions of the clinical problems would be considered. Selection of appropriate segments was based on the number of lessons associated with the particular segment. Additionally, since students are not required to take Level III examinations, performance was analyzed on only those exams completed by a reasonable number of students. Nearly all students take the first several Level IIIs, and fewer students take the exams near the end of the academic year. However, in terms of the relationship between curriculum units and basic science lessons, a limited number of lessons existed (in 1975-76) which were associated with material learned in the latter portion of the year.

After the above factors were considered, 17 groups of lessons relating to portions of the SBMS-UC curriculum were identified. However, since no individualized lesson usage data existed until mid-October, performance on the first two clinical problems and its relationship to usage of the PLATO lessons could not be examined. This constraint reduced from 17 to 12 the number of areas in which lesson effectiveness could be scrutinized.

With assistance from Project authors, it was also possible to associate lessons with some portions of a college-constructed certifying examination (Freshman Comprehensive). The 62 PLATO lessons applicable to four specific areas contained in this exam were analyzed.

Summary of Data

Based on the 12 analyses conducted data from only one analysis (Microbiology of Peptic Ulcer) revealed significant performance differences favoring the user group. In the remaining analyses, it was generally observed that although some performance benefits accrued to users of the lessons, differences between users and nonusers were not significant. In addition, no performance benefits were found to exist for students who had used PLATO lessons related to subtests on the College Freshman Comprehensive.

For 1976-77 the procedures described above (except for the Freshman Comprehensive) were duplicated. Of 19 analyses performed, three (Anatomy, Pharmacology twice) demonstrated significant differences favoring users and one (Microbiology) demonstrated a significant difference favoring nonusers. All remaining analyses showed no significant differences.

Accomplishment of Contract Objectives

Due to space limitations, the specific text for this section has been deleted. The text is available from the author on request.

Major Factors Which Impacted Upon Project Functioning

A number of factors impacted upon the Project and affected its ability to attain many of the contract objectives. Some of these factors, such as the ECS crisis, were outside of the control of Project management. Additionally, even with careful planning, it would not have been possible to anticipate the consequences of these events. It is also important to note that the PLATO IV system was itself in an experimental stage of development when the Project was begun. For example, the TUTOR language was evolving rapidly. The fluidity of the language created problems when Project staff and management attempted to develop and implement programming standards to which lessons must comply. Other aspects of the Project's functioning, such as defining realistic objectives, hiring staff, implementing effective lesson development and review procedures, and establishing liaison relationships with personnel external to the Project, should have been within the control of Project staff and management.

Relative to factors which affected the Project, one of the major ones was the contract itself. Since Project staff did not participate in the formulation of the contract, it is suggested by the evaluators that this factor was largely beyond the control of Project staff and management. The scope of the contract outlined objectives which were somewhat unrealistic given the resources requested and awarded and the short three-year time frame agreed upon for the accomplishment of objectives. For example, monies existed for only five full-time equivalent (FTE) authors (four were ultimately hired) who were expected to develop lessons to cover the greater portion of the SBMS-UC curriculum which contained 12 basic science disciplines. Project management and staff recognized the enormity of their task. Yet, at the same time, no systematic and clearly defined operational plan of action was implemented to allow them to approach their task in a directed manner. The total complement of four authors was not available for full-time participation until approximately one year after contract monies were awarded in July of 1973. The recruitment of qualified staff was expected to occur in July and August of 1973. However, by that time, most competent individuals had secured positions for the next academic year. Thus, one year of the Project's three-year tenure was spent without a full authoring staff.

After the Project was staffed, authors generally worked without the benefit of guidance in the selection of topics for lesson development. Authors spent considerable time during the life of the Project developing such procedures. Authors indicated that because of the absence of a clearly defined plan of action, the Project shifted directions on many occasions. As the Project shifted directions, author responsibilities changed and, as a direct result, it was difficult to maintain sustained efforts in lesson production. Further, authors carried out their instructional duties without the sustained participation of a full-time educational/instructional design specialist.

When Project administration recognized the improbability of meeting contract objectives, the scope of the Project was expanded to encompass the development of a multinodal network. It was hoped that participation of

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faculty at other institutions would lead to the development of a larger body of lesson material to which a diverse cadre of students could react. It was also decided by Project management that the Kansas pharmacology materials would be translated to PLATO IV. Authors felt that these expansions of the contract required time and effort which could have been devoted to their production of basic science lessons. Yet, two of the major accomplishments of the Project were the establishment of the network and the translation of the Kansas materials.

Having to provide on-the-job training was also a major factor which impacted upon the overall productivity of the Project. No formal training programs in the TUTOR language were offered by the developers of the PLATO IV system. Consequently, training programs within the Project had to be developed, but these were found lacking in that authors felt a need for more in-depth training in the TUTOR language, programming, and instructional design. Contrary to popular belief at that time, the TUTOR language was found difficult to understand and use proficiently. Authors spent most of the second year of the contract learning and improving their skills in TUTOR and basic instructional design. Unfortunately, this necessary year of on-the-job learning was not planned for in the contract.

Another important factor which affected the Project's successful implementation was its difficulty in establishing effective liaison relationships with faculty at the School, allied health professionals, faculty external to the School, and students. To produce lessons which would conform to specifications within the contract, authors should have had input from these individuals during the lesson selection, development, and review process. Further, because faculty at the School participated only minimally in these activities, they would not recommend lessons to students and few references were made to the lessons in the School curriculum. Because of the absence of strong liaison relationships with School faculty, the Project had throughout its tenure a truly adjunct status and was, for the most part, peripheral to the educational process within the School. It is not clear whose responsibility it was to establish more satisfactory liaison relationships, but without them, the Project and its lessons were not integral parts of the School's instructional process.

Project Accomplishments

When Project accomplishments as they related to the specific contract objectives were reviewed, it was seen that no one objective was achieved completely. Many factors affected the Project's functioning and impacted negatively on the production of lessons. However, if Project functioning is considered on a macro level with less emphasis on the specific contract objectives, a number of contributions can be identified. These contributions are described briefly in the following paragraphs.

One of the Project's major accomplishments was that it demonstrated that PLATO IV was a usable and viable instructional system in the basic medical sciences. For example, student users at SBMS-UC felt that Project-authored lessons were good supplements to the basic science curriculum. Students indicated that lessons helped them learn basic science concepts. They also requested that additional lessons be developed. Further, it was generally observed that some higher level of performance on examinations was achieved by lesson users as compared to that of nonusers. These differences, though for the most part, were not significant.

The Project also demonstrated that many features of the PLATO IV computer system could be utilized effectively as a learning medium. Most of the courseware that was developed did, in some way, capitalize on the interactive, innovative capabilities of PLATO IV. For example, students indicated that they especially liked interactive lessons and lessons which graphically simulated complex biochemical reactions. Additionally, with the conversion of the Kansas pharmacology materials, the Project exhibited that PLATO IV was an excellent host for lessons developed on another computer system. Based on the estimates of one Project director, the Kansas materials were converted to PLATO at 10-20% the cost of creating lessons de novo. Further, there are some indications that the converted courseware ran more effectively on PLATO than it did on its parent system.

Another major contribution of the Project was the role it played in the dissemination of information about PLATO IV to the CAI health science community. When the Project began in 1973, little was known nationally about PLATO IV. At that time, the prevalent attitude was that the system was expensive, as well as difficult to use and understand. However, partly through the efforts and demonstrations made by Project personnel at national meetings and conferences, the PLATO IV system is now a sought after commodity.

After it became apparent that the goals outlined in the contract could not be accomplished within the specified time frame, the concept of the multinodal PLATO IV health sciences network was born. It was thought that if a number of institutions became involved in the development of lessons, the original scope of the contract might be achieved. With the addition of network sites, more content expertise would also become available. If other faculties were to become involved in initial lesson production, then the exportability of lessons might also be facilitated. The evaluators believe that the Project's plan of having network sites participate in the initial development and use of courseware was a novel and exciting idea. Potentially the inter-network lesson development process could help solve one problem which exists currently on most other CAI networks--that lessons cannot be of any instructional value or possible use unless they have been produced at the home institution. Unfortunately, not enough monies, personnel, and time were available for the full implementation of the networking concept.

In summary, the Project did contribute to the available body of PLATO IV courseware and was successful in demonstrating that the system was viable for computer-assisted instruction. The multinodal network concept was a good strategy, and some of the Project's lesson development-procedures and systems could be used elsewhere.

Recommendations

The primary purpose of this section is to provide recommendations which may be useful to individuals considering or planning the development of a project similar to the Computer-based Education Project. The recommendations cover a variety of aspects ranging from qualifications of staff, on-the-job training programs, and the need for a 6-12 month funded planning and recruitment phase. Data from diverse participants, such as Project directors and authors, and experiences of the evaluators relative to program development shaped the formulation of these recommendations. It is hoped that the reader will gain insight into the diversity of factors that interact to influence the successful development and implementation of an educational program.

Recommendation 1: A minimum of a 6-12 month funded planning and recruitment phase is critical to the successful development of the Project.

To expect a complex CAI project to be fully functioning immediately after the contract has been approved and funded is unrealistic. A period of time for operational planning and staff recruitment is necessary. During this planning period, operational goals should be defined, a plan of action for achievement of goals should be developed, time frames for the accomplishment of objectives should be estimated, and Project staff should be recruited and hired. Training programs should be developed and should include training in the programming language, basic instructional design, and fundamental instructional concepts. Intensive programming training should be developed for those individuals who will computerize lesson designs.

During this funded planning and recruitment phase, the basic design of lesson development and review procedures should be outlined. The existence of well-designed procedures will guide authors in their lesson development activities and will reduce the length of the interval between when authors join the Project and when they can produce lessons which meet the specifications contained in the contract. Additionally, if lessons are to respond to the needs of various user groups, input from the physician community, basic scientists external to the Project, allied health professionals, and student users should occur during the selection, development, and review of lessons. Thus, the foundations for effective liaison relationships between Project staff and other groups should be built before staff joins the Project.

Recommendation 2: In order to encourage optimal Project functioning, the Project should be developed and implemented in such a way that it is an integral and meaningful part of the School's educational process.

As observed with the Computer-based Education Project, the adjunct status of the Project contributed negatively to its functioning. It appears now that the adjunct arrangement contributed to many problems, including the unwillingness of School faculty to recommend lessons to students or reference lessons in the curriculum document. If a project is to succeed and if its lessons are to be used substantially, then the project must be recognized academically and its authors must be viewed as productive professionals. Further, nonproject basic scientists within the School should participate in the selection of topics for lesson development. If these interactions are to occur, then formal liaison relationships must be implemented. The existence of mechanisms to facilitate interactions is essential if faculty are to aid authors in identifying basic science deficiencies of students and if the lessons are to become an integral part of the instructional process.

Of all the suggestions offered, that of incorporating the Project into the educational process is by far the most difficult in terms of recommending actual functional arrangements to accomplish the goal. It has been suggested that academic departments hire and control authoring personnel. Within the department, the author would be required to produce instructional materials (lessons). Evaluation of authors would be based on the instructional merit of lessons with rewards and promotions contingent primarily upon the production of high quality lessons. Productive authors would receive the same respect and rewards given currently to productive researchers.

Other individuals have recommended that Project authors hold joint appointments in departments, but that the academic department would only participate in the recruitment of the author and would not control his/her lesson development activities. Authors stated that some bench research and classroom instruction (perhaps as much as 20-30% of their appointment) should be part of their responsibilities and that these activities should be carried out within the context of a department. They felt that research would allow them to remain abreast of developments in their field. Instructional duties would keep them attuned to student needs, and thus, facilitate lesson development. Authors would be rewarded primarily for excellence in lesson production.

Both of the recommendations outlined above require acceptance of and commitment to the concept of differentiated staffing with equivalent promotions, stature, and rewards given for either instructional or research contributions. At present, within this University, professionals are promoted primarily on research productivity. The likelihood that differentiated staffing will be implemented is remote--or, as one colleague stated, "The chances are slim to none."

Recommendation 3: Define the resources necessary to meet the objectives outlined in the contract and explicated in the plan of action.

The definition of resources should encompass both personnel, hardware, and physical facilities. Relative to personnel, it appears that approximately 10-15 authors (full-time equivalents) were needed to develop 300 lessons distributed among 12 basic medical science disciplines. Authors suggested that one programmer to one author was optimal. Two secretaries are needed to accommodate the demands of a Project with the number of personnel suggested by authors. One director and an associate director should be hired. The director should provide content-centered leadership to authors and facilitate development and implementation of liaison relationships. The associate director should handle the daily administration of the Project and work with the director on matters of long-range planning and maintenance of liaison relationships. Because of the instructional nature of the Project and the importance of evaluation, a full-time instructional/educational specialist, as well as a full-time evaluator, should be members of the Project staff.

Physical facilities should include a separate office per programmer-author pair. Authors noted that developing a lesson required the same concentration as preparing a journal article. Authors also suggested that a terminal in each office is needed. Work space should also be available with two or three terminals for conferences and demonstrations. Physical facilities should be proximal to student and faculty work areas to facilitate interactions among authors and these other individuals.

Recommendation 4: Special attention should be given to defining the qualifications of Project staff and hiring competent individuals.

As noted in Recommendation 3, a Project director and an associate director are needed. The director should provide academic guidance to authors and assist them in the selection of topics for lesson development. This individual should possess either an M.D. or Ph.D. degree with experience in the basic sciences, innovative education, and medical education. An understanding of clinical medicine is also needed to ensure that authors will be encouraged to include aspects of clinical medicine in their lessons. The associate director should be skilled in the administration of educational endeavors. It would be desirable for this individual to have had previous experience within a college of medicine. This experience would help him/her understand relationships among basic science faculty, administrators, physicians, and departments. This knowledge would enable the associate director to facilitate the development of liaison relationships. Hiring a director and an associate should receive first priority. These individuals, then, would have the primary responsibility for ensuring that additional high quality staff would be acquired.

Authors should possesss a Ph.D. degree in a basic science discipline and, hopefully, have some expertise in more than one area. Authors should have had some experience in a college of medicine--preferably delivering instruction to medical students. Such experience would allow the author to have a perspective within which the instructional needs of medical students could be understood. It would also be desirable if authors had some experience in innovative instruction, either in the development or delivery of instruction. Additionally, it is essential that the author have a strong commitment to instruction and innovation in medical education and an openness to CAI as a potentially valuable medium for delivering instruction. If a competent programming staff is available, it is less important that authors have computer experience.

Relative to the programming staff, if authors are to spend the major portion of their time designing lessons, a competent programming staff is essential. Programmers should carry the burden of translating lesson designs into computerized materials. Authors felt that full-time programmers were more satisfactory than part-time graduate student programmers who were detracted frequently from their (Project) work because of academic demands. Further, authors suggested that a programmer should be assigned to each author. It was also noted that programmers should have some basic science training, as this background would help them translate lesson content into a computerized form.

A full-time instructional specialist with training (and, preferably, experience) in computer-assisted instruction should also be hired. The specialist would work with authors on the design of pre-tests, post-tests, educational objectives, and mastery learning. The specialist would also provide valuable perspectives on lesson design and instructional techniques. A full-time evaluation specialist is also needed.

> Recommendation 5: The second year of Project functioning should be devoted to training staff, implementing lesson development and review procedures, and building liaison relationships.

At the beginning of the second year, all Project staff should be available for full-time participation. During this year, activities should center on intensive training and familiarization of staff with the medium, the programming language, and instructional design. It is also important that Project staff understand the contract goals and how these will be translated into action. To some extent, authors should assist the directors in formalizing the Project's plan of action. This should help authors develop a sense of ownership and increased understanding of the Project's goals.

In addition to the training of staff, Project management, with assistance from authors, evaluator, and instructional specialist, should develop and implement fully lesson development and review procedures and programming standards. It is essential that such procedures and standards exist if the product (lesson) is to be of high quality, both instructionally and scientifically. These procedures will not guarantee quality, but the probability of producing high quality lessons will be increased if such mechanisms are utilized. Lesson planning and development should include input from the instructional specialist, programmers, students, basic scientists, allied health professionals, and physician consultants. In the review phase, additional input from these participant groups is also critical. Since lessons should respond to the instructional needs of students, input from students and teaching faculty should be sought. Participation of physician consultants is encouraged because these persons can provide important insights into the correlations between the basic sciences and clinical application.

Review of lessons by content experts external to the institution where the Project is developed is important. These experts should provide feedback about the scientific integrity of lesson content, as well as the potential value of lessons to students other than those at the home institution. If lessons are to be applicable to health professions students, other than the first year basic science student, allied health professionals should be members of the expert review group. Review by faculty within the home institution is also critical because valuable information on the relationship of lessons to the non-CAI curriculum can be gained. Additionally, the accuracy of content can also be evaluated. Participation of faculty at the home institution may also increase their willingness to accept the lessons and recommend them to students.

> Recommendation 6: An over-emphasis on performance-based criteria as a measure of lesson effectiveness should be discouraged when the Project is implemented in an environment where students are encouraged to use multiple learning resources.

It is difficult, if not impossible, to measure the impact of lessons on subsequent performance when students utilize a variety of learning resources in their pursuit of basic science knowledge. Other criteria of lesson effectiveness should be developed, but should include student usage of lessons. Attention might be given to measuring the value of lessons for laboratory simulation or determining how quickly students can master a concept presented via the computer as opposed to acquisition time via another medium. The belief that CAI is a form of instruction suited to all students should be discarded. No single learning resource seems to be an ideal tool for every student.

> Recommendation 7: The collection of meaningful lesson usage data requires high overhead in software and programmer resources. The collection of these data should be planned for and developed at the beginning of the Project.

This recommendation really speaks to the need to plan for the evaluation of lesson effectiveness at the outset of the Project. Of course, this requires that a general evaluation strategy be developed. An evaluation specialist is needed to assist in the design and implementation of these procedures.

Relative to the evaluation of the Project, lesson usage data should be one small part of an assessment of the outcomes. Attention should be given on how the Project functions, its management programs, the qualifications of its staff, etc. A complex endeavor cannot and should not be evaluated on the basis of a single index, such as usage of lessons. Further, data from diverse groups should be gathered. Information from these individuals will offer many perspectives of the Project and its products. Formative (on-going) evaluation is essential and can provide useful information to Project personnel about weaknesses and strengths and allow personnel to take action during the Project's operation to improve the weaknesses and further strengthen successful aspects of the Project. Summative (end-product) evaluation should also be incorporated into the total evaluation plan.

Recommendation 8: Development of a network (multinodal sites) seems essential to the exportability of lessons.

Authors reported the prevalence of the attitude of faculty at other medical schools that if the lessons were not developed by those faculty, then the lessons could not possibly be of sufficient quality to permit their students to use them. Participation of faculty at other sites seems to be a reasonable method to foster the growth of feelings of lesson ownership. If these same individuals also reviewed lessons developed at other sites, then there might be less reluctance to allow students to use the lessons. Further, if the goals of the contract are substantial in scope and if the number of authors is increased via the development of multinodal sites, then it may be more likely that the goals of the contract could be attained. Additionally, having lessons developed at various sites may allow the lessons to have maximum generalizability to other curricula.

The benefits of networking as described above seem clear. However, there are several potential risks. If the network is to produce an integrated quality automated curriculum, then procedures to ensure communication among developers and enforce lesson development/review procedures must be implemented. Without such controls, the possibility exists that lessons will be redundant, disjointed, and of greatly disparate quality. Further, the implementation of an effective network requires substantial time and effort on the part of Project staff and administration.

Unresolved Issues

At least two questions remain unanswered in the evaluators' minds. The first is, "Could PLATO IV or any other educational computer system have a major role in delivering a substantial part of basic science content to first year medical students?" Will it ever be possible to eliminate or reduce the prevalence of the attitude that an educational computer system should be peripheral to the delivery of instruction to medical students, i.e., that lectures and textbooks are the only media effective for transmitting knowledge? Secondly, is it feasible to expect that basic scientists who devote their attention to the development of high quality instructional materials will be respected by their colleagues and rewarded within the university community for their contributions to instruction? Answers to these questions seem to have considerable import for the success or future of innovative instructional projects in medical education.

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References

1. Hody, G. L., Levy A. H., PLATO IV Applications in the Basic Medical Sciences - Part I, May 19, 1976.

2. Hody, G. L., Project Quarterly Report to NIH Contract Officer, May 1, 1974.

3. Levy A. H., An Interim Report, Computer-Based Medical Education: Processes and Potentials, July, 1976.

4. Provus, Malcolm M. The discrepancy evaluation model. In: Peter A. Taylor and Doris M. Cowley (Eds.), *Readings in Curriculum Evaluation*. Dubuque, Iowa: Wm. C. Brown, 1972.

5. Sorlie, W. E., Project Quarterly Report to NIH Contract Officer, November 1, 1973.

6. Stake, Robert E. An approach to the evaluation of instructional programs (Program portrayal vs. analysis). Paper delivered at the American Educational Research Association Annual Meeting, April, 1974.

7. Stake, Robert E. Responsive evaluation. Unpublished paper, December, 1972.

8. Stufflebeam, Daniel L. Evaluation types and a model for evaluation. In: Daniel L. Stufflebeam, Walter J. Foley, William J. Gephart, Egon G. Guba, Robert L. Hammond, Howard O. Merriman, and Malcolm M. Provus (Eds.), *Educational Evaluation and Decision Making*. Itasca, Ill.: F. E. Peacock, 1971.

9. Winer, B. J. *Statistical Principles in Experimental Design* (2nd ed.). New York: McGraw-Hill, 1971.

Medical Student Authoring of Medical Lessons on PLATO

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ABSTRACT

Computers are intrinsically fascinating to students once they learn what materials are available and they master the mumbo-jumbo associated with signing in. The Plato Health Science Network contains an extensive catalog of lessons of interest to medical students and is available to anyone who requests, resulting in several hundred hours per week of lesson usage.

A by-product of this high usage is that students become interested in creating lessons both by authoring scripts and by programming the computer. Historically this student interest has been discouraged as irrelevant to the process of becoming a physician. However, because of student persistence, their participation in the lesson-writing process has come to be accepted and even encouraged by the staff of the Medical Plato Project.

Student participation in authoring has resulted in a substantial number of quality additions to the clinical offerings of Plato. Specific examples of student work are described along with projects in progress and planned. In addition, contributions of student authors toward faculty involvement in CAI are noted.

INTRODUCTION

Computer Assisted Instruction at the Abraham Lincoln school of Medicine is used "smorgasbord style" for the most part, at the student's own initiative. Computer lessons are rarely assigned as class work. Since medical students are acutely aware of the necessity to pass the year-end comprehensive exam, however, they make good use of available computer lessons which fulfill their educational needs, just as they make good use of available lectures, textbooks, and clinical experiences.

The CAI system used at the College of Medicine is Plato, a nationwide network of terminals connected to a Control Data Corporation Cyber 73 at the University of Illinois in Champaign-Urbana. Twenty-two plasma-graphics terminals are available for student use at the Chicago Medical campus, in eight locations including the Health Science Library, a student study area near the classrooms, a learning resource area, and five Chicago teaching hospitals. Each student receives a personal signon. Upon keying in this signon, he sees displayed on the terminal screen the "Plato Health Science Network" main index. From this display he chooses various categories of lessons to study. Altogether he can access over 500 Plato lessons, ranging from the differential diagnosis of a pregnant diabetic to how to author a lesson on Plato.

Student usage of Plato lessons is increasing. In the school year 1975-1976, medical students logged 4504 hours of academic use at Chicago. In 1976-77, 7468 hours of academic use were logged. In 1977-78, as of mid-October, 2902 hours of use have been logged, for a projected total year usage of about 14,500 hours.

A number of reasons exist for this high rate of usage:

- there is a selection of several hundred lessons available on the catalog;
- terminals are widely and easily accessible;
- periodic mailings and a freshman orientation make students aware of this resource;
- word of mouth among students generates interest;
- Plato is intrinsically fascinating to students;
- Plato fulfills educational needs. Not only do students currently studying at the College of Medicine use Plato, but also future students: last year soon after acceptance letters went out for the new class, several premeds called to find out if they could get Plato signons before classes began six months hence.

HISTORY OF MEDICAL STUDENT AUTHORING

Concomitant with student interest in existing Plato lessons in the early days of the Plato medical project came student complaints about areas of the curriculum with insufficient coverage, student ideas for new lessons, and student interest in authoring. However, student overtures were not received favorably. Administrators felt that Plato could not be expected to cover the full range of the medical curriculum, that students did not have the background to suggest new lessons, and that future doctors had more important things to do than write up computer lessons, even medical computer lessons.

Despite such skepticism, students found their way into the lesson-writing structure. A pediatrician at one of the teaching hospitals called and said he wanted to write a Plato lesson -- could he have space, a signon, and a manual? No, he didn't want to talk to a programmer or an instructional designer; he had all the help he needed: a medical student was working with him.

In fact, of course, the medical student did the whole lesson -- the pediatrician just verified the technical data. Their lesson, added to the medical catalog despite experienced advice, became one of the most popular clinical lessons on Plato for the next two years. The previously prevailing accepted "format of choice" for clinical decision-making exercises was never used on Plato again. However, a dozen lessons were written in the next two years using this new format, and a dozen new formats were spawned in the wake of this tradition-defying innovation. As for the validity of this new instructional design: it has been adopted for a new program of continuing medical education on Plato at the University of Illinois.

Gradually the staff of the Medical Plato Project realized that student authoring was not necessarily an evil. In fact, the staff found that it could accomplish several major goals by encouraging students to author Plato lessons:

1. Student utilization of the terminals would increase.
2. Areas of need in the CAI curriculum would be diagnosed.
3. Use of CAI in medical education in the long run would be encouraged, since today's students are tomorrow's teachers.
4. Available formats would be expanded by tapping the creative imagination of highly educated, talented, and internally motivated users.
5. Faculty participation would increase, at least their level of awareness of Plato activity, since students would be calling on faculty to review their programs.

METHOD

When Plato staff determined in late 1976 that student authoring was worth encouragement, they immediately established some authoring procedures for students to follow and publicized these procedures. The staff decided that students must have a faculty sponsor. This rule discourages gamers, involves faculty, and inhibits weaker students from escaping their rigorous medical studies in the labyrinth of programming. Rules were written up and incorporated into an agreement students must sign to secure their author privileges (see Appendix).

In addition, all publicity about Plato was rewritten, such as student handout sheets, an introductory computer program, and bulletin board postings, to promote student authoring. All students on campus received a flyer including an invitation to learn about authoring.

At the incoming student orientation meeting in Autumn, 1977, authoring was mentioned in the course of the usual introduction to Plato in medical school. Periodic student mailings will continue to mention authoring. When students seek out the Plato office and ask questions, their interest in creating programs is always assessed. Such efforts, coupled with the intrinsic attractions of Plato as an intricate machine and a "typewriter that talks back" have attracted numerous student authors, including student government leadership.

The Plato staff offers interested students programming assistance and instruction, manuals, help on proposals and reviews, and printout facilities for files being worked on. The staff has also responded to student requests for more terminals, terminals in more convenient locations, and for longer hours such as access on Sunday morning.

RESULTS

In the 1974-75 school year one medical student wrote a clinical simulation about the differential diagnosis of pediatric gastro-intestinal hemmorhage. It was enthusiastically received by users of the Plato Medical Network. As a result of student efforts, therefore, one faculty member became involved in lesson development.

In the 1975-76 school year, eight medical students worked in lesson development and completed three clinical lessons. Two of these lessons used the format developed the previous year by a student, with the script being written by students and the programming done by the Plato staff. One was a diagnostic simulation of "The Malabsorption Syndrome" in medical pathology; the other was a diagnostic simulation of a patient with a brain tumor, in the area of nuclear medicine. The third lesson was programmed by the student himself using a format of his own design, and all the content was provided by the student. As a result of these efforts, six faculty members became involved in lesson development on Plato, and in turn involved their colleagues.

In the 1976-77 school year, nineteen students became involved in authoring lessons at the Chicago campus. Five lessons were completed in the course of the year, and six more were finished during the summer. Fifteen additional faculty members learned of Plato through these student efforts, and four faculty wrote Clinical Simulations for Plato to further expand the material available on the Medical Catalog.

The lessons written by students reflect a broad range of topics and formats. One first year medical student who had an undergraduate computer science major wrote a lesson about interpreting electrocardiograms.

He devised his own interactive format and the lesson received substantial use, filling a particularly acute gap in the catalog.

Another student wrote a laboratory simulation about the use of enzyme assays in diagnosis which included a number of didactic help sequences, a "Hall of Fame" for top scores, and the highly interactive quality of gaming. Users of the lesson can play at four levels of expertise, with varying specificity of clues provided at each level. Scores can be stored in the Hall of Fame only if the user is playing at the highest level.

A third lesson resulted when two student government leaders undertook a comparative survey of the quality of student experiences in ten teaching hospitals affiliated with the University of Illinois. Students rated these hospitals on 63 dimensions such as quality of teaching, facilities available, and type of experience. The student government officers, along with a third medical student who is an experienced Plato programmer, then wrote a lesson which allows students to compare up to three hospitals on given dimensions, or to compare two hospitals with the average ratings of all hospitals. Data are available either in raw responses, in percents, as numbers or as histograms. This lesson is heavily used in the Autumn quarter when the clerkship lottery determines which students will be assigned to which hospital. (Note: new data were provided for the 1977-78 school year to enable comparison with the 1976-77 data). It is important to emphasize that this lesson was conceived and programmed by students and that the data were gathered by students as well. In fact the Plato staff became aware of this lesson only after the work was done and the students wanted to have it added to the catalog.

Another lesson conceived by a student and programmed by him is a "Medical Ethics Simulation" consisting of a number of moral dilemmas confronted by physicians, such as teenage sex and contraception, diagnosis of terminal illness, and use of drugs. Many of these dilemmas have no right or wrong answer, nor do they have any certainty of outcome. Students in going through the lesson are called on to choose from a number of alternatives to resolve an issue. Feedback to the student about the problem's outcome is randomly selected to simulate the outcomes of similar situations in real life. Cumulative statistics are kept on choices made by the lesson users so that a cumulative profile of student ethics as measured by the lesson is available.

Other student lessons include a game type of interactive drill on generic names and brand names of drugs, particularly important to clinical students because of the multiplicity of terms currently used and being introduced; a series of scripts about the diagnosis and management of patients in orthopedic surgery; a University Medical Student Council Newsletter utilizing the unique capabilities of Plato's notefiles for interterminal discussion; a lesson about the diagnosis and management of hypertension; a lesson about glycogenolysis; and a lesson about pediatric cardiology. These lessons, like all lessons added to the Plato Health Science Network catalog, will of course undergo review both to insure factual accuracy and to certify that no programming errors interfere with their use.

In the 1977-78 school year, as of October 1, 33 students are involved in writing and programming Plato lessons. Of these students, eight have completed at least one lesson which was added to the Plato Health Science Network catalog in the last year. Six new lesson proposals have been accepted so far this year, in addition to a large number of carry-over projects from past years. Four first year students are still working on their introductory programming exercise, but they all have concrete ideas about a project they wish to complete, ranging from simulating a patient with perceptual deficit to a startrek-based inter-terminal game between viruses and bacteria in the bloodstream rather than between Klingons and Romulans in the universe,

CONCLUSIONS

Faculty and administration often approach Computer Assisted Instruction as a tool to remediate academic deficiencies among disadvantaged students. They usually do not anticipate that "better" students will become involved in CAI both as consumers and producers of courseware. Our experience has been that disadvantaged students use Plato, much as other students do, and in about the same intensity as they use the library or other study aids.

However, just as better students stand out in class discussions, in lab work, in independent study, or on rounds, so do they stand out in the medium of CAI. Furthermore, due to the infancy of CAI and its inchoate institutionalization into the curriculum, there are as yet no set limits to its uses. Thus student programmers in this new and experimental medium are free to innovate and explore the limits of expression which can be attained. That widely diverse formats have come forth and new types of computer applications to medical education have multiplied attests to the efforts and genius of the medical students who have found their way to author mode on Plato.

APPENDIX
RIGHTS OF AUTHORS

1. Any Medical student at the University of Illinois may obtain an author signon by meeting the following conditions:

a) obtain a faculty sponser who will agree in a letter to supervise your development of lessons on Plato and oversee the content of your lessons for accuracy and clinical relevance.
b) sign the University of Illinois Author agreement forms.
c) sign this form upon receipt of your signon indicating your acceptance of the obligations.

2. Authors are entitled to a work file as long as they remain in good standing.

3. Programming assistance is available in the form of the two TUTOR manuals, on-line consultation, and face-to-face help from CED programmers where possible.

OBLIGATION OF AUTHORS

1. Authors agree never to enter a lesson without the permission of the author of that lesson.

2. Authors agree never to execute lessons on the medical catalog using their author signon. In order to properly keep data, the student signon should always be used for instructional lessons including the medical notefiles.

3. Authors agree NEVER TO PLAY GAMES DURING PRIME TIME. Infractions of this rule may result in one months suspension of author privileges.

4. Authors agree never to write obscene, derogatory, or libelous notes in the note files or through the comment or talk options.

5. Authors agree never to use any signon except their own.

6. Authors must never lend their signon to anyone.

I, ________________________________, agree to the conditions stated above and promise to abide by the rules and regulations of PLATO in using my author signon.

X ________________________________

Date: ____________________________

Medical Terminology Matching Drill (EPONYM)

Timothy C. Hain

ABSTRACT

A driver program was developed to teach medical eponyms and generic/commercial drug names to medical students. The students are presented with multiple choice questions generated from a subject pool of about 20 bidirectional defined:definition pairs. Each frame is generated by random choice drawing from two sources ; an intermediate subpool of five active items and from the whole subject pool irrespective of active:retired status. Correctly answered question items are retired and errors are ressurected. Immediate feedback for errors and correct answers is provided.

INTRODUCTION

The medical vocabulary is a large and difficult one to learn. A subset of that vocabulary, eponyms - diseases,syndromes,procedures etc. named after men who supposedly discovered them - comprise a large and sometimes usefull portion. Eponyms are characterized by the lack of cues linking one member of a definition:defined pair to the other ... e.g. Crohn's disease:granulomatous enteritis. The acquisition of knowledge of eponyms thus is primarily a process of rote memorization - a process ideally suited to a codified computer based learning strategy.

Numerous tutorials to teach new materials as well as drill and practice algorithms have been described. The EPONYM algorithm is a hybred being a drill and practice format incorporating abundant feedback intended to be capable of functioning as a primary source of medical definition knowledge.

This algorithm is an outgrowth of a 'corrective feedback paradigm and criterian teaching model' PLATO lesson called 'feedback' (referred to in the text as CFP), written by M. Siegel and A. Misselt. CFP was written as a 'fill in the blank' driver driver and due to the nature of the free text definitions in EPONYM the author decided to develop an alternative algorithm incorportating his own ideas as well as those applicable from CFP. CFP utilizes feedback, retirement, and randomization in a more deterministic framework than the algorithm to be described here.

EPONYM ALGORITHM

The program was written to run on the PLATO system requiring about 4000 words of extended cores storage.

Main groups of (definition:defined) pairs reside on a pageable disc memory structure (PLATO dataset). EPONYM can access 400 of these pairs in subject oriented subgroups of about 20 apiece.

The student requests a main group of N definitions which is paged into his personal accessible storage. A N by 2 bit flag array is defined which contains one flag for each definition or defined item. This array is used to flag active:retired status.

Then the question format of 'defined is' or 'definition is' is randomly chosen. If the number of retired defined's or definitions greatly exceeds the other, the format is chosen accordingly.

A subgroup of the first five active items of the proper format is then considered. From this subgroup four answers are chosen at random. To this list one more answer is chosen at random from the entire main group irrespective of active:retired status. A question matching one of the five answers is randomly chosen and displayed. Four answers from the list are displayed and 'none of these' is displayed as the fifth choice. A student response is awaited.

```
If the number of attempted answers = 1 then
    If the answer is correct then
        Write 'exactly, '(defined(correct) is (definition
             (correct))'
        Retire item(correct) by setting flag(correct) to correct
        Return to question format choice step.
      Else If the answer is incorrect then
        Write 'no (defined(wrong)) is (definition(wrong))'
        Ressurect (wrong) and (question) by setting flag(wrong)
             = flag(question) = wrong
        Return to arrow.
      Else if key is HELP goto the HELP unit explaining
             what is expected from the student.

If the number of attempted answers > 1 then
      If the answer is correct then
        Write 'ok (defined(correct)) is (definition(correct))'
        Return to question format page.
      Else if the answer is wrong then
        Write 'defined(wrong) is definition(wrong)'
        Await another answer.
```

As N-4 items or more become retired, items are chosen at random from the entire main group until all items have been retired. Then the student is given the option of storing his score if either of two conditions are met : 1) his score is better than any previous score for this subgroup or 2) ten days have elapsed since the last storage of a score for this main group. The student is congratulated (or derided) according to his preformance and is returned to the lesson index page where scores are prominantly displayed.

DISCUSSION

The EPONYM paradigm has been implemented in two PLATO lessons

- the origional EPONYM incorporating about 400 definition pairs and later GENERIC including about the same number of drug trade:generic name pairs. Both have seen substantial student interest in an atmosphere of self-selected study of the PLATO medical catalog. In about a year of time on the system, EPONYM has seen 2058 users and 362 hours of use. GENERIC has seen 1427 users and 288 hours of student use in about 8 months of on-catalog time.

The program's subgrouping strategy was based upon consideration of the problem of optomizing learning of a group of more or less nonsense word group pairs. In a straight line drill and practice algorithm learning of new material even if immediate feedback is provided is often difficult due to wide separations between unlearned challenge items. A randomized D&P with replacement of missed items may fail due to the same problem. A rigid format consisting of repitition of challenge items until appropriate response is obtained and at predetermined intervals thereafter is appropriate for a 'fill in the blank' algorithm but is deficient in a multiple choice environment due to predictability.

One solution to this problem lies in the technique of considering only a small number of unretired items as a subpool from which to draw upon - thus the student methodically progresses frame by frame through the main group considering only a limited subpool at any time whose former members are now retired and new members drawn from the general population.

An additional twist found helpful in this program is the addition of one question drawn from the main group at large as a further source of unpredictability and a check upon guessing.

Program reaction to errors must also be precisely defined. By using the word ressurection I mean that something more complicated than simple replacement is used in response to errors. The first student answer is taken to be most valid and is the only answer used for ressurection purposes, answers following being good only for student information. In a bidirectional format such as this one, an error implies lack a bidirectional lack of knowledge. Therefore on an error, both defined's and definitions of the (wrong) item are replaced as well as the question. Early in the progression through a subgroup this will result in no change to the flag array. Late in progression this may result in replacement of all three items. Slower students are plagued with frequent late ressurection resulting in subgroup backtracking while faster learners can rapidly progress through the subgroup in an almost linear fashion and complete the main group in a minimum of time.

In addition it was felt that the lesson should cover a substantial fraction of the total amount of material of this type. This was achieved by the use of a pageable memory device - the PLATO dataset.

Mastery of materials is encourged by the competitive aspects of the scoring system. A score is formulated as (fraction correct) ** 3 x (time/items). In the case of 0 errors thus score reduces to time per item. Some humanization of the program was attempted by referring to the student by logon name and some encouragement/deridement based on the student's score for that group.

Improvements on this algorithm, for the PLATO system at least, must remain in the context of limited core storage and time slice per user. During peak use hours on the PLATO system, the program slows down significantly which of course throws the timed scoring system off.

Increased adaptability to student capabilities might be obtained thru in-program expansion or contraction of the size of the subgroup pool. Also, numerous program parameters (subgroup size, main group size, random choice frequency,ressurection method) were chosen through a somewhat intuitive approach by the author. Data gathering while varying these parameters might yield better values. Individual optomization of multiple parameters might be worthwhile in a large scale use of an algorithm like this.

CONCLUSION

Formidable amounts of rote memorization of basic medical vocabulary can be taught by feedback algorithms such as the CFP of siegel or the one described in this paper. Subgrouped question pools combined with of randomization can upgrade the primary learning capability of the conventional drill and practice algorithm.

REFERENCES

(1) Stedman's Medical Dictionary, 23'd edition, 1976

(2) Index to Computer Assisted Instruction, Lehan, 1970, Sterling Institute

(3) "A Corrective Feedback and Criterian Teaching Model for CAI Drills",Unpublished paper,Computer Based Education Research Laboratory,Siegel,Martin A and Misselt,A. Lynn;1975.

(4) Tutor Manual, Bruce Sherwood, 1974

AN INFORMATION SYSTEM FOR CAREER COUNSELING AND GUIDANCE IN THE HEALTH FIELDS: SOME CONSIDERATIONS FOR PLANNING

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Introduction

Health care is a profession encompassing a variety of personnel. The National Library of Medicine classifies the following broad areas of programs: medicine, dentistry, allied health sciences, osteopathy, optometry, and podiatry. The formal preparation time ranges from one year general programs to subspecialty requirements spanning many long years. Other areas under the very broad classification of administration or management support are almost too numerous to list. These range from housekeeping to sophisticated computer science and electronics, nuclear engineering, with complicated diagnosis and care management techniques growing by leaps and bounds. A whole new business science is developing around such areas as the coding of insurance claims for faster turn-around time or disbursement, Medicare and Medicaid profile structuring of average charges, and encoding cancer diagnoses and treatment the entire life of each patient for satistical research.

With the propigation of HMO's (Health Management Organizations) and the advent of some form of National Health Insurance, the health care industry is concerned with management through good health as well as care for those in the opposite condition. Young people, especially those entering a health field program for the first time, must make career decisions and plan viable alternatives of a flexible nature. This report will present some of the more salient characteristics of an information system which would facilitate appropriate decision-making by supporting, or intervening with, a valid career counseling process. Primary concern will be with those entering the system the first time, although some thought will be presented in support of those wishing to replan or construct alternative career directions, as well as about career mobility, i.e., growth in the field.

I. Decision-Making

A career is like motion and is viewed as being the "time-extended working out of self" by Ellis and Tiedeman (11, p. 354). A career is not just a person's job, but is the context for "the expression of hope and desire and limitation upon life" (11, p. 354). Most often there is a problem or some difficulty with deciding as the result of freedom of choice in the act of inscribing one's career road map.

"The relationship between an individual and his occupation is, in many ways, similar to the relationship between an individual and his marriage partner. Both partners contribute to meeting the needs of each other; both impose demands upon the other" (12, p. 117). This places the focus by counseling and information systems supporting those endeavors squarely upon the individual.

In order to help each client deliberate about who he is and what he wants to become, Healy (8, p. 67f) listed eight replicable career counseling procedures: systematic planning, interpretation of empirical data, reinforcement, self-acceptance, specificity of problems and goals, on-going evaluation of process, transferability of acquired (problem solving) skills, and peer modeling. The one principal limitation to this individually-oriented format is direct input by others involved in the client's career, such as family.

A part of the career planning process, and placing more demand upon a comprehensive information system, is the aspect of career mobility. The development of viable alternatives does not always imply initial entry redirection. A plan of growth may entail sequencing or phasing of progress as the result of such factors as available funds, family status, or proximity of study facilities which may, themselves be in phases. Many institutions now make career step ladders available, and entrants to health careers should have access to related information as a function of long-range planning.

II. Information Systems

Career information needs to be systemized for individual understanding and use, structured at a rate and depth harmonious with the individual's development, and presented or displayed in a manner facilitating selection of pertinent information to enable internalizing by the individual. What should result is integration--the individual interweaving attitudes about himself and the external career information.

The format of an information system applicable to the cause herein discussed may take the shape of a classified library or move along a continuum of formats to any property that is useful in the creation of useful sets for the ultimate benefit of the search process. In this case, the logistics of the information structure become just as important as the content of the component items. A heuristic search may manage with items representation that is less intensively "descriptive" than in a batch search system. This is because the enquirer is not "at arms length" from real text and may, therefore, be tentative in his request for information. Barker et al. (Journal of Documentation 28:1 3/72 44-55) find that recall rises, at the expense of precision, with an increase in searchable text. A search of titles plus keywords, or titles plus digest, retrieves more relevant material than a search of titles only. The authors maintain that this technique could be refined to enable a user to specify a required level of performance--very beneficial to career information searching. The burden of abstracting may be reduced by utilization of "terse conclusions" which further aid the searcher.

Ideally, this hypothetical information system would interface with almost any cost-effective form of media. The all-too-familiar shelves displaying colored brochures can be insufficient for incentive building. Multi-media have found their way into the classroom, and surely have proven their value in concept building, transference, instant time-compressing, etc. From computer controlled audiovisual devices to printed materials, with live presentations for individuals or groups, the most appropriate form of communications should be used. Individual carrels with dial access to video or audio libraries with accompanying software could enable the user to explore a wide range of possible interests. Compressed speech with a slide display facilitates "stop and go" searching. With a short film or video tape, a "case history" presentation can induce realism about any specific career area including personality (temperment) and other profiles of a typical professional. Computer terminals can perform interest surveys and other tests, with hard copy available if desired.

The final decision as to materials format, location, size of collection and budget allocation should be made with the concept that accessibility is a detriminant of extent of use, which is in turn related to skills, intellectual level and maturity of potential users (10, pp. 127f & 14). "For materials to be considered to be accessible by the user, identifying, locating, retrieving, record keeping, and returning will all need to be accomplished in a minimum of time" (10, p. 128).

Housing for the multimedia resource center is considered to be a function of numbers of users. This can be a section of a regular library or separate facilities located in close promimity to the guidance offices. There should be ample room for both individual as well as small group utilization, along with storage facilities, resource center offices, maintenance area, etc. Security is a matter for concern, but ensuring that users will be able to locate materials is more important. Personnel available for assistance should be well-trained and unbiased. Rather than the physical connotations of housing, the concern is for the environment being psychologically strong and the information system comprehensive, available in many media, and highly accessible to potential users.

III. Career Counseling Criteria

Most direct benefits derived from career counseling can be classified as information processing, planning, and execution (8, p. 76f). Contacts with and knowledge of informational resources (as discussed above) equal awareness. Attitudes about obtaining information, realism of self-concept and self-esteem all effect judgment in determining exactly what it is a person wants to be.

Planning factors such as acceptance of responsibility, realism of plans and ability to solve career problems all affect the feasibility of a complete career plan containing strategies and objectives. Certainly the satisfaction from proper execution factors will be a direct result of the seed planted in the beginning by the career information system.

IV. ISVD (Information System for Vocational Decisions)

The united States Office of Education granted funds to Harvard University for the only project in history of the use of computers at that time to go so far in relating guidance functions to advanced notions relating to information processing, data storage and retrieval, and natural language processing, etc. (6, p. 122f). With the computer we have the potential to make guidance less hurried, less directive, and even less factual. Instead of "legitimizing" outmoded practices such as paper shuffling through automation, the approach was to look beyond guidance practice to guidance theory; specifically a theory of career development.

A career is not just a job or past and present related activities. It is a purpose imposed upon those activities and of a time-extended nature. The decision-making process, central to a career, is divided into anticipation and accommodation. In Ellis' summation of Tiedeman's paradigm (6, p. 127) he states: "The anticipation aspect consists essentially of a person's preoccupation with the pieces--facts, alternatives, options, consequences--out of which a decision is to be fashioned and with the aspirations, hopes, expectations, constraints, and the like which will determine the form of the decision." About the accommodation aspect, he says: "The aspect of implementation or adjustment--represents the movement from anticipation to induction; it is the point where imagination meets reality."

Very important to the basic concepts of an information system are the "subaspects" or stages of anticipation. Exploration begins with awareness that a problem exists and a decision must be made about a number of different alternatives or possible goals. Crystallization represents a stabilization, or ordering of all relevant considerations such as the potential return for each goal. Choice is elected with varying degrees of certainty affected by clarity, complexity, and freedom available (directly related to the information system). Clarification is the final stage of anticipation, and is a necessary projection of self into the image of the future in order to dissipate doubts about the decision.

This model of a decision-making process, and the posited relationship between it and career development are primarily "to get the individual to take title to his career" (6, p. 129). In order to encourage a sense of responsibility, ISVD proposed to place students among resources and enhance their access to them, i.e., an environment called an information system. The search time must not hamper decision-making, therefore the computer is expected to store large amounts of data and make them immediately and selectively available as the individual proceeds through the decision-making process. As stated previously, the structure must facilitate creating order as the searcher browses. Probing, suggesting; enabling the following of leads in the manner of a simulator or game player, the system becomes a mediator to connect the counselor to the student. ISVD was not a project about computers.

Planning the educational orbit involves both academic and clinical institutions. In fact, many employers provide more than clinical training sites; formal and informal programs are initiated as part of the education process. Herein lies a problem--recognition of these institutions as part of an academic tract, or educational orbit. All educational institutions must provide intersystem coordination for the sake of organized, reliable, and shared information. (Already, Texas networks exist for the purpose of sharing library and learning resources.)

For the study of degree and non-degree programs, resources (institutions and the programs they foster) should be shared. Clusters of related careers in a core curriculum should give advantages to students and the institutions. In the process of centralizing faculty, better definition of career directions would be possible with the student in mind, as opposed to adherence to a particular school with choices limited as a function of existing "in-house" programs. This could also feed back into the shared information system in the form of a higher degree of specificity of career information.

Manpower projections of the supply of and demand for a number of emerging and radically changing occupations are severely limited by the storage of data on their functions, roles, or acceptance. Educational planning by institutions must be based on realistic representations of these projections. The information system, at a minimum, should be able to furnish valid projections of not only positions and numbers, but location as well. Immediately or sequentially adjacent should be salary ranges, training requirements and cost ranges for that training. A very realistic need is for information concerning available financial aids for undergraduate studies (17). Some authorities believe that the proper goal for manpower planning should be the overloading of the market in order to give the health care industry a better choice in personnel, as opposed to the current condition.

V. Study of Health Manpower by the Connecticut Institute for Health

Of the many different sources queried the largest return percentage was from employers and health education institutions (5). The state medical and dental societies were not included as the result of time deficiencies and non-acceptance of the data gathering instruments. However, other organizations and societies did participate. In general, the capacity of existing educational programs was deemed sufficient, as was the number of students enrolled. Continuance of on-the-job training by hospitals for low level of specialty positions remains a problem as related to lack of transferability to other institutions. The basic concept of a career ladder is being introduced, however.

One recommendation by the state commission was the establishment of some vehicle for coordinating the activities of educational and clinical institutions. (Even disagreement on job titles vs. curriculum labels causes confusion, results in over-training, say the employers (5, p. B-19).) Not the least of the supportive activities suggested is development of an on-going health information system (5, p. B-23). This was called "an information-system/job bank." The commission extended special emphasis by stating that $80,000.00 was already available from license and certification fees, plus the fact that The National Center for Health Statistics is developing such a system. Included in this data bank the committee wishes to have training opportunities and the costs involved. These are highly essential for educational resource regional long-range planners to see that both types and numbers of properly trained personnel are ready when and where needed.

VI. Predictions: Trends in Health Occupations and Implications in the Delivery System

In each decade since 1940, employment in health rose 50%, reaching 5 million today. By 1980 we are projected to need 7 million (7). In spite of slow-downs, we are not short of money, and where there is money to pay, services will be provided. Even a shortage of highly skilled personnel is met by furnishing more narrowly trained personnel, but in greater numbers.

Growth in the health care industry is the result of these three factors (7, p. 2):

(1) Hope: technical and scientific advances enable people to get a great deal out of the health industry.
(2) Affluence: a national health insurance will eventually come, making the manpower boom created by Medicare minor by comparison.
(3) Super-annuation: due to a decrease in birthrate, we are becomming an aging nation, plus having older people a longer time. Older people, like old machinery, require a lot of care to keep them functioning.

Frey goes on to say: "With these factors of population, increased useage, dollars and aging continuing, we will have continued need for expanded education of both conventional and new types of health personnel, regardless of the system" (7, p. 2).

There is a shift of emphasis, with the accent on ambulatory care, for rehabilitation kinds of workers with a decrease in acute care kinds of people.

Management of people, diagnosis systems which are computer based, primary care workers backed up by sophisticated communications equipment, and environmental workers will increase. (Be sure your information system has a good handle on this latter one--needed but Washington does not know where or when.)

As the result of scientific and technical innovations, a large number of new career slots will appear. More automation of the laboratory; new sallies in radiologic technology (radiant energy, ultra-sonics, thermography, nuclear medicine, etc.) plus computer-assisted diagnosis. (Right now in San Antonio is a relatively new industry called Avionics. Heart patients walk the streets with a small, expensive tape recorder connected for vital signs and constant recording of EKG. In the event of trauma, these recordings are fed into a computer in Indiana which has its data base and program up-dated every four hours. Capital outlay by the physicians founding such an enterprise: a little less than a half million dollars. Yet, the profit first year-end will be of interesting size.)

Changes in the delivery system are evident in the increase in HMO's. Emphasis will be on the profit side, i.e., keeping people well and out of the acute care side. Manpower implications are many: just a few are dieticians, diagnosis workers, medical records clerks (many), and health sociologists (can relate to an enormous system and manage people through it).

New emphasis on quality control will immediately require education to individualize instruction as the result of the system being evaluated and not the people. Relevancy of education outside the industry to the needs of the job will greatly increase. The demands upon the information system/counseling process will be amplified. ". . . to change our ways in health care delivery, preparation to work in delivery has to change as well" (7, p. 11).

VII. Opportunities for Empirical Research

There well may be opportunities for development of a strong rationale for the existence of an information system/resource center as it relates to research on the entire health career counseling process. The following list is intended as only a small sample of potential research areas:

A. Incentives and attitudes as affected by the multimedia resource system. (Psychology, physics, communications)
B. Human information-processing (visual, audio literacy): (virtually the entire campus from Engineering to Communications to Instructional Media).
C. Evaluation, accountability of career guidance system: (Educational Psychology, Statistics--even the School of Business).
D. Structure, impact of Multimedia Resource Center: (Instructional Media, Library Science, Educational Psychology, Architecture, etc.).

E. Library Science approaches to indexing, abstracts, descriptors, etc.:
(Library Science and Information Science would both embrace Computer Science for this one).
(Perhaps even the Department of Transportation would need to do a traffic management study.)

VIII. Summary

The inherent value in the information system will be ascertained via a feedback system. The principal question to be answered is: will a surface level penetration into a field (or inquiry to what-ever depth) enable the user to make valid career choice decisions? Appropriate to this question is a point of difference between data (facts) and information (facts interpreted in relation to use) (11, p. 359) with the particular challenge to structure the Resource Center and its content to best aid the user.

The five principal components of the content of the total system should be:

(1) Possible career directions (plus typical qualifications and training, physical requirements, temperment).
(2) Training facilities available (plus entry requirements and average costs).
(3) Funds or other assistance for study.
(4) Manpower predictions shaped in terms of average preparation time-frame.
(5) Comprehensive counseling.

Compiling data, deriving information sources, up-dating, and structuring materials for optimum display will be a demanding task. Studies by states such as Connecticut (5) call for information systems and the health manpower planning required by institutions to be coordinated on a national basis.

Bibliography

(1) American Hospital Association: "Career Mobility: A Guide for Program Planning in Health Occupations": Pub., AHA, 840 N. Lake Shore Dr., Chicago, Ill., 1971.

(2) American Library Association: "The Library and Information Networks of the Future": Pub., ALA, 50 E. Horon Street, Chicago, Ill. (Prepared for Rome Air Development Center, AF Systems Command, USAF Contract No. AF 30 (603-2578, Griffis AFB, New York.)

(3) American Medical Association: "Compendium of Military Allied Medical Education": Council on Medical Education, Chicago, Ill. Feb. 1974. ERIC # ED 089 123.

(4) Brammer, Lawrence M. and Shostrom, E. L.: "Therapeutic Psychology": Prentis-Hall, Inc., 1968.

(5) Connecticut Institute for Health Manpower: "Study of Educational Programs and Employment Opportunities in Health in Connecticut and the Northeast and Overview": Hartford, Conn., 1974. ERIC # ED 095 807.

(6) Ellis, Allan B.: "The Use and Misuse of Computers in Education": McGraw-Hill, 1974.

(7) Frey, Don C.: "Futurism and Health Occupation Education": The Implications of Changes in the Delivery System": Dec. 1973, ERIC # ED 091 502.

(8) Healy, Charles: "Career Counseling in the Community College": Publ, Charles C. Thomas, Springfield, Ill., 1974.

(9) Herr, Edwin L., and Cramer, S. H.: "Vocational Guidance and Career Development in the Schools; Toward a Systems Approach": Houghton Mifflin, 1972.

(10) Hollis, Jospeh W. and Hollis, Lucile U.: "Personalizing Information Processes: Educational, Occupational, and Personal-Social": The Macmillan Co., 1969.

(11) Holtzman, Wayne H., Editor: "Computer-Assisted Instruction, Testing and Guidance": Harper and Row, 1970.

(12) Isaacson, Lee E.: "Career Information in Counseling and Teaching": Allyn and Bacon, Boston. 2nd Edition April 1972.

(13) Lekan, Helen A., Editor: "Index to Computer-Assisted Instruction": Sterling Institute, Feb. 1970. 2nd Edition.

(14) Liesener, James W.: "District and Regional Learning Resource (Media) Programs: A Systematic Planning Process and Exploratory of Services." Final report of a project, Division of Instructional Resources, Texas Education Agency. 1975.

(15) Lewis, Ann: "Occupational Analysis of Computers in Medical Sciences": California State Employment Service, Sacremento, June 1969.

(16) Lorenz, Robert B.: "Coaching the Education of the Health Care Term": Audiovisual Instruction, Vol. 16, No. 8, Oct. 1971.

(17) Maxwell, Bernard G., M.D., Editor: "Current Financial Aids for Undergraduate Students": Pub., College Opportunities, Unlimited, Inc., 824 N. Cooper, Peoria, Ill., 1969.

(18) Mikhilov, A. I.: "An Introductory Course on Information/Documentation": Pub., International Federation for Documentation, The Hague, Netherlands, 1971.

(19) Tucker, Norman E., and Rydland, L. Norman: Co-Editors: "National Conference in Multimedia in the Health Sciences": Publ, Educational Communications Foundation, Inc., Fairfax, Va., 1971.

A Comparative Evaluation of Computer-Managed and Instructor-Managed Instruction

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The U. S. Navy is currently operating the largest computer managed instructional (CMI) system in the world. Approximately 5,500 students located in eight different schools in four separate locations are managed by the system each day. The management functions performed include; test grading, extensive record keeping, remediation, prescription of study assignments, and monitoring of student progress. The system is projected to expand considerably in the next five to ten years, therefore, Navy training managers are continually interested in obtaining reliable information concerning its benefits and effectiveness.

To date only one experimental study of the Navy system has been accomplished. Carson, Graham, Harding, Johnson, Mayo, and Salop (1975) did an initial evaluation in two short courses taught at the Naval Air Technical Training Center in Memphis, Tenn. CMI was compared to (a) conventional classroom instruction and (b) a student-paced system based on the instructional and test materials developed for CMI, but which substituted instructor performed operations for some of the computer provided operations. The latter procedure was designated instructor-managed instruction (IMI). Carson, et. al. (1975) found that both CMI and IMI reduced training time by 50 percent, and slightly improved scores on criterion referenced knowledge tests, relative to classroom instruction. There were no differences between the CMI and IMI conditions on either of these measures. This may have been due to uncontrolled variables that minimized differences between the groups. In addition, the experimental design and preconditions precluded a precise comparison between CMI and IMI in terms of instructor duties and activities (e.g. time spent grading tests, time spent counseling, free time, record keeping, etc.).

The present study also compares an instructor managed and a computer managed version of a Navy Technical course. However, unlike the Carson, et. al. (1975) study, conditions permitted tighter experimental control and an analysis of instructor activities.

Background. The study was conducted at the Propulsion Engineering School at Great Lakes, Illinois. The Propulsion Engineering School is the "A" school for three engineering ratings: Machinist's Mate, Boiler Technician, and Engineman. The curriculum for all ratings is completely individualized. All testing is criterion referenced, and hands on training occupies 30 percent of each student's instructional time. The curriculum is divided into modules. The first 13 form a common core of basic knowledge and skill units which students in all three ratings take. The opportunity for the present study arose when the first 13 modules were scheduled to be placed on the CMI system. The plan for CMI implementation did not involve any changes in the existing instructional or test materials, therefore, a relatively well controlled comparison of the old instructor-managed course (IMI) and the CMI system could be made.

The main difference between the IMI and CMI versions of the first 13 modules was in testing and remediation procedures. Three types of tests are given in the course: (a) lesson tests are given at the end of lesson within a module, (b) module tests are given at the end of each module, and (c) a comprehensive test is given at the end of the first 13 modules. Under CMI, all tests are computer scored and remediation statements are printed out for missed questions. Under IMI the comprehensive and module tests were instructor scored and remediated. Lesson tests were scored by the students; the answers were provided in the test booklet. Thus, IMI students could elect not to take the lesson tests or could just look up the answers in the test booklet.

The present study controls for this discrepancy between IMI and CMI procedures by including an IMI group (IMI-control) in which instructors scored and remediated lesson tests. Two additional groups were run: (a) the CMI group and (b) an IMI group (IMI-conventional) in which students followed normal school procedures and scored their own lesson tests.

Method

Subjects. Subjects were 300 students enrolled in the Propulsion Engineering school at Great Lakes, Illinois. Sixty subjects were eliminated due to incomplete data and random elimination to equate the number of subjects per group. The remaining 240 subjects were divided into 3 groups of 80. Subject assignment to groups was not entirely random. Because IMI and CMI were never run simultaneously (IMI was phased out before CMI was implemented) subject assignment was confounded with time of year. However, the two IMI conditions were run together and subject selection for these conditions was random.

Procedure. The experimental manipulations for the CMI and IMI-conventional groups required no change from the normal school procedures already described. For the IMI-control condition lesson tests were instructor scored and remediated, students were required to use the op-scan answer sheets used in CMI, and instructors were provided with a listing of the remedial statements given by the computer under CMI. In all conditions instructors were asked to record the amount of time spent in various activities each day.

Dependent measures included (a) module test scores for all three conditions (b) lesson test scores for the IMI-control and CMI conditions (c) comprehensive test scores for all three conditions (d) time to complete the course for all three conditions and (e) time instructors spent on various activities.

Results

Module Test Scores. A 3(groups) by 13(modules) analysis of variance was performed on module test scores. The only meaningfully significant difference was for modules, $F(12,2772) = 66.76$, $p<.001$. This finding indicates that some modules are more difficult than others.

Table 1

Percentage of time spent by instructors in each group in instructional and management activities

	EXPERIMENTAL CONDITION		
INSTRUCTOR DUTIES	IMI-control	IMI-conventional	CMI
Correcting Tests	50	25	11
Remediation	11	28	15
Counseling	9	6	23
Reviewing Records	9	13	6
Instruction	10	10	20
Orientation	8	6	6
Free Time	2	12	19

Lesson Test Scores. A 2(groups) by 30(lesson tests) analysis of variance compared lesson test scores for the IMI-control and CMI conditions. There were no significant differences.

Comprehensive Test Scores. A one-way analysis of variance done on comprehensive test scores for the three groups was significant F(2, 264) = 6.54, $p<.005$. Means for the groups were; CMI = 87.95, IMI-control = 90.75, IMI-conventional = 90.59. A post hoc Tukey (b) analysis revealed that the CMI group scored significantly lower than the two IMI groups, which did not differ.

Course Completion Time. A one-way analysis of variance was performed on number of class days to complete the first 13 modules for the three groups (weekends and holidays were excluded). There were no significant differences, however, CMI students averaged approximately one day less than IMI students. Means for the groups are: CMI = 13.57, IMI-control = 14.49, IMI-conventional = 14.64.

Instructor Activities. Table 1 presents the percentage of time spent by the instructors in each group in various instructor activities. It is clear that CMI increases free time and decreases test correcting relative to IMI. It should also be noted that free time was almost eliminated in the IMI-control condition while test correcting increased 25 percent relative to the IMI-conventional group.

Discussion

In general the results agree with the findings of Carson, et. al. (1975). There does not appear to be any major performance differences between the CMI group and the IMI groups. However, the small (three percent) but significant difference in comprehensive test scores in favor of the IMI groups was unexpected. One possible explanation for this result is the Armed Services Vocational Aptitude Battery (ASVAB) scores for the CMI group may have been significantly lower than scores for the IMI groups. This condition is attributable to the fact that the student population of the school differs as a function of time of year. Students attending in the fall and winter months tend to have higher ASVAB scores than students attending in the spring and summer months. The IMI data was collected in the late fall while the CMI data was collected in the early summer. Unfortunately, ASVAB scores for the CMI students used in this study were unobtainable because of privacy act restrictions, however, data obtained from a similar group of CMI students shows that their ASVAB scores are significantly lower than scores for the IMI-control and conventional students $t = 2.49$, $p<.05$. Mean scores are: CMI (summer) = 491, IMI-control and conventional (winter) = 503. Thus, the difference in comprehensive test scores could reflect ability differences among the groups.

The course completion time data indicates that CMI does result in time savings. Although there were no significant differences for course completion time CMI subjects completed the course one day faster than IMI subjects, on the average.

CMI also resulted in more free time and less test scoring for instructors. This result has important implications for instructor training and the instructor's role in an individualized CMI environment. If the time saving advantages of CMI are to be realized the role of the instructor must be examined in depth and changes in instructor scheduling and training must be made. For example, the instructor could be trained in academic counseling of slow learners or in techniques for motivating students in the impersonal individualized CMI situation. Requiring instructors to obtain and use skills such as these would make productive use of time saved by CMI.

References

Carson, S. B., Graham, L. L., Harding, L. G., Johnson, K. A., Mayo, G. D., & Salop, P. A. An evaluation of computer managed instruction in Navy technical training. San Diego: Navy Personnel Research and Development Center, June 1975. (Technical Report TR 75-38)

TICCIT APPLICATIONS IN HIGHER EDUCATION: EVALUATION RESULTS

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INTRODUCTION

Full-scale operation of the TICCIT$_{TM}$* computer based instructional system began in the 1975-76 academic year. The TICCIT system departed substantially not only from traditional classroom instruction but also from the adjunctive mode of instruction in which many other CAI systems had operated. In order to assess the impact of TICCIT upon the educational process, the Educational Testing Service (ETS) conducted an evaluation comparing the effects on community college math and English students of TICCIT and traditional instruction during the demonstration period covering the first year and a half of full TICCIT implementation. The data collected by ETS at community colleges in Phoenix, Arizona, and Alexandria, Virginia, and observations after the initial evaluation, including data from TICCIT applications at Brigham Young University, demonstrate that even in its initial period of operation students on TICCIT learn very well; in fact, in almost every case students in "mainline" TICCIT courses learn significantly better than comparable students in traditional lecture classes.

Positive achievement results consistently occur in both math and English applications. Students in mainline TICCIT English classes scored significantly higher on objective tests of writing skills and also scored better on essay tests than lecture students. Likewise, in five of the six different math courses in which TICCIT was used during the evaluation, students on TICCIT scored significantly higher on posttests than did their counterparts in lecture sections. Not only did the math students perform better on posttests measuring cumulative learning, they also achieved higher scores for topical tests administered during the term to evaluate immediate learning.

The evaluation and subsequent experience with TICCIT has shown that its effect upon students, especially the effect upon completion rates, is very highly dependent upon the environment in which it is implemented. The most important aspect of the environment appears to be the manner in which the instructor manages student interaction with the system. In most TICCIT mainline English classes instructors generally took an active role in diagnosing problems, assigning special work, and conducting small discussion groups to solve common problems. Such efforts resulted in completion rates during the demonstration period that approached those found with the lecture sections. As experience with the system increased, completion rates with the mainline English application surpassed the rates found in lecture, the TICCIT rates generally in the range of 70% to 90%. Similar results were found in the few math courses that were also conducted in a similar manner; the rates for TICCIT classes managed by an instructor familiar with the TICCIT system also surpassed traditional classroom rates. However, during the evaluation none of the math classes included management procedures similar to those found in English. Completion rates for math in those TICCIT courses were considerably lower than lecture rates. A slight negative impact upon achievement was also found in TICCIT English classes that used TICCIT adjunctively, although the completion rates were close to those of lecture sections. From the observations of TICCIT so far, it appears fair to conclude that the individualized TICCIT instruction will have a significantly positive effect upon student achievement and that student completion rates are affected by the level of management introduced by the TICCIT instructor, with rates higher than lecture rates possible with a comprehensive management program.

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* TICCIT (Time-shared, Interactive, Computer-Controlled Information Television) is a trademark of Hazeltine Corporation.

The remainder of this paper presents an overview of the background and design of TICCIT, a summary presentation of data from the ETS evaluation, and the developer's view of the data and their implications.

BACKGROUND

In 1971, the Office of Technological Innovations in Education of the National Science Foundation, in order to investigate the impact of computer-assisted instructional systems upon community college education, contracted with the MITRE Corporation to develop and demonstrate the TICCIT$_{TM}$ (Time-shared, Interactive, Computer-Controlled Information Television) system in a community college environment. An independent evaluation of the educational impact of the system was to be conducted by the Educational Testing Service during the 1974-1976 school years.

In order to accomplish its task, the MITRE Corporation engaged instructional design and CAI experts from the University of Texas CAI laboratory and Brigham Young University (BYU) to work closely with its own system engineers in the design,

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development, and implementation of the TICCIT CAI system. MITRE engineers were primarily responsible for the hardware and software development; the Institute for Computer Uses in Education at BYU, which then included those who were the key members of the University of Texas development team, directed the development of the freshman-level mathematics and English courses used in the demonstration. Assisting in the specification of those course materials were English and Math faculty from both of the community colleges selected as the demonstration sites, Phoenix (Arizona) College of the Maricopa County Community College District and the Alexandria Campus of the Northern Virginia Community College.

SYSTEM DESCRIPTION

An important aspect of the project was the effort expended developing TICCIT's reliable and inexpensive display system. A brief physical description of the system must include the fact that the system is powered by a pair of mini-computers which direct the retrieval of various types of information, including digital text/graphic displays and audio messages, to be broadcast to the student's terminal, which includes a standard Sony television set, student keyboard, and optional light pen. The use of the television permits an extensive use of color in the digital displays as well as the use of full-color motion video (e.g. video tapes) and broadcast television.

The TICCIT project was concerned not with the development of a new hardware system but of a new instructional system. Therefore, a significant portion of the TICCIT project research was directed towards the development of an effective individualized instructional delivery model. The resulting model is a unique combination of new ideas and highly tested instructional design principles, some of which are briefly described below.

Mainline courseware. TICCIT is not designed to be used as an adjunctive resource to supplement regular classroom instruction but to be used as the primary source of the delivery of instruction. The role of the teacher is intended to be that of manager-advisor, working with individual students in tasks such as selecting goals, diagnosing problems, prescribing special assignments , holding limited classes in subject areas causing particular difficulties, and, in general, providing the motivation required to overcome inherent pacing problems in such an individualized system. TICCIT administers and evaluates all the primary instruction and lesson tests, provides students with inter- and intra-lesson advice concerning learning strategy, and provides instructors with student performance data.

Mastery. The testing on TICCIT requires all students to attain a specified level of achievement in each lesson. Each student spends as little or as much time as necessary to reach that goal; one aim of the system is to provide for each objective enough material at differing difficulty levels to allow students of divergent entry levels to achieve mastery.

Separation of Content and Strategy. The analysis of research conducted in connection with TICCIT and other projects indicated that the effectiveness of a particular learning strategy is independent of subject matter. The model of instruction implemented on TICCIT and found to be most effective in promoting mastery of the types of objectives used in academic course work is based, among other things, on the presentation for each objective of a generality statement, examples of the generality, and practice problems. The example and practice items are present in large numbers, insuring to the student the presence of a divergent set of instances at different difficulty levels. In addition, every generality and instance is further explained in detail through the use of "feedbacks" and "helps."

Not only does the separation of content and strategy provide the student with a consistent learning environment for each objective, but it also eliminates the need for the subject matter expert/author to be involved in lengthy determinations of teaching strategy. The built-in learning strategy makes possible a team approach to authoring, allowing a differentiated staffing scheme for cost-effective courseware production. Those highly trained in subject matter and instructional design perform only creative tasks, such as lesson specifications; routine formatting and data entry are completed by a specialized production staff.

Learner Control. Within the structured design of instruction, the student exercises control over the pace of instruction, the sequence of instruction, and the strategy of the instruction for each objective. From all of the instructional components available, the student chooses the type and quantity he/she wishes to see. The student is assisted in this responsibility by an on-line "advisor" which attempts to inform the student what options would appear to be reasonable based on the student's past performance.

ETS EVALUATION-INTRODUCTION

Although original project plans called for evaluations of costs, technical achievements, and educational impact, the final ETS report is concerned only with the latter. In order to judge the system's impact upon education at the community colleges, ETS compared students in traditional classes with students in the same courses taught on TICCIT. Because of the mainline nature of the TICCIT system, the comparison was sharply defined; students on TICCIT, although still directed by an instructor, generally received all or nearly all of their instruction on-line, while non-TICCIT students were instructed in the traditional manner, receiving instruction from textbook and lecture. Although the evaluators had no control over class composition, students often chose TICCIT or non-TICCIT sections on what might be considered a semi-random basis, and in the evaluator's estimate, class composition did not appear to create any bias toward either the TICCIT or non-TICCIT condition. The measures of educational impact included student achievement, completion rates, student and faculty attitudes, and student and faculty activities.

At the time this paper was written, the evaluation report was only partially complete. The chapters available included the two most important for purposes of this discussion, student achievement and completion rates. The following two sections summarize the data reported in those two chapters.

STUDENT ACHIEVEMENT

Measures. In order to compare the effects of TICCIT upon cumulative learning, identical posttests were administered to all students finishing the identified math and English courses; differences in test scores between TICCIT and non-TICCIT sections indicated the effect of the TICCIT program upon achievement, with an effect of 4 points representing an approximate difference in outcomes of ten percent of the test's total possible score. For math courses, the evaluation looked not only at the total score across items which tested objectives common to both treatment conditions, but it also examined achievement in terms of subscores for ability levels, such as problem solving ability, and content categories, such as linear equations. For English courses the posttest was divided into two distinct parts, an objective test of writing skills and an essay test.

Because of the apparent different natures of cumulative and immediate learning, the evaluation included provisions for testing immediate learning in the math course. The test for such learning consisted of a topical test to be administered to the students as soon as the material to be tested were completed by the student.

Populations. In reporting the achievement data for English sections, comparisons are not made between the entire group of students enrolling in the two conditions. In both TICCIT and lecture sections, less than the entire group of enrollees finished the course, and neither of the groups that did finish was representative of the entire population enrolled in the respective course. For both conditions, the entrance ability of those finishing was greater than those not finishing. However, compared to each other the groups were similar; therefore, student achievement comparisons are between the students completing English on TICCIT and those completing lecture sections.

In mathematics fewer students completed the course on TICCIT than did with lecture, and the average entrance ability of the students finishing within one academic term was higher than that of the students finishing lecture sections. Therefore, the initial comparison for math posttest achievement results was between the group completing TICCIT within one term and similar students (based on entrance ability) completing lecture classes. For additional posttest analysis, the population was substantially enlarged by including in the analysis scores of the many students completing TICCIT courses during a second academic term. A larger comparison group was also used in the analysis of topical test achievement.

Results -- Math. The tables on the following pages include samples of the pretest and posttest observations of students completing math and English courses. The data presented represent observations within academic terms. The analyses for both math and English were completed on a class-by-class basis, but because of the large number of TICCIT math students who had pretests in one term but completed the course and posttest in a subsequent term, math achievement results were also analyzed at the course level ignoring the time constraints of individual terms. The first table presents data from the math courses. The analysis for the single class data (completions within a term), taking entrance ability into account, shows a positive TICCIT impact on achievement in eight of the eleven cases, two cases showing significant positive impact. However, as stated above an analysis was also completed which dropped the time constraints of a single academic term to permit the inclusion of the scores of many math students who re-enrolled in a second term to complete the course. The inclusion of these students not only increased the number of pretest-posttest observations but also improved the size of the applicable populations. For example, in the fall quarter of beginning algebra at Phoenix the mean pretest score for students completing TICCIT courses within one term was 44.86 while the mean pretest score for those who began the course in the fall term but completed during the spring term was 33.92, nearly one standard deviation lower.

TABLE 1

ACHIEVEMENT SUMMARY
MATH
Academic Year 1975-76

Course	Term	Comparison Group	All Pretests N	All Pretests Mean	All Posttests N	All Posttests Mean	Pretest-Posttest Observations Pretest N	Pretest-Posttest Observations Pretest Mean	Pretest-Posttest Observations Posttest N	Pretest-Posttest Observations Posttest Mean
Phoenix										
007	Fall	Total	415	37.26	182	39.42	152	41.80	152	39.32
		TICCIT	161	35.32	27	44.26	22	44.86	22	43.32
		Lecture	254	38.49	155	38.58	130	41.28	130	38.64
	Spring	Total	332	36.24	181	38.96	172	39.05	172	38.78
		TICCIT	110	36.15	35	40.57	32	40.06	32	40.09
		Lecture	222	36.28	146	38.58	140	38.82	140	38.49
Alexandria										
31	Fall	Total	195	31.72	58	38.90	52	38.19	52	39.27
		TICCIT	90	31.56	9	45.33	9	47.22	9	45.33
		Programmed	47	29.74	7	34.86	4	36.50	4	34.75
		Lecture	58	33.59	42	38.19	39	36.28	39	38.33
	Winter	Total	105	30.00	62	38.53	46	34.09	46	39.07
		TICCIT	41	27.29	25	40.00	21	34.33	21	40.86
		Programmed	33	32.21	16	38.56	10	34.00	10	39.10
		Lecture	31	31.23	21	36.76	15	33.80	15	36.53
	Spring	Total	130	29.01	38	38.83	32	38.37	32	38.56
		TICCIT	41	30.12	11	40.36	9	41.33	9	40.56
		Programmed	58	26.14	16	36.44	14	33.21	14	35.79
		Lecture	31	32.90	11	40.73	9	[illegible].33	9	40.89

TABLE 2

ACHIEVEMENT SUMMARY
ENGLISH
Calendar Year 1976

Phoenix

		All	Pretests	All	Posttests	Pretest-Posttest Observations			
						Pretest		Posttest	
Term	Comparison Group	N	Mean	N	Mean	N	Mean	N	Mean
Objective Test of Writing Skills									
Spring	Total	283	23.17	147	26.39	131	24.49	131	26.73
	TICCIT	126	21.87	49	27.94	47	24.30	47	27.81
	Lecture	157	24.22	98	25.61	84	24.60	84	26.12
Fall	Total	479	22.89	318	26.31	276	23.62	276	26.26
	TICCIT	182	23.99	123	27.45	87	25.37	87	27.53
	Lecture	297	22.22	195	25.60	189	22.82	189	25.67
Essay Test									
Spring	Total	300	2.02	145	2.14	137	2.08	137	2.14
	TICCIT	124	1.96	49	2.26	47	2.10	47	2.26
	Lecture	176	2.07	96	2.08	90	2.08	90	2.08
Fall	Total	506	1.91	320	2.09	297	1.99	297	2.08
	TICCIT	208	1.88	117	2.08	99	1.95	99	2.07
	Lecture	298	1.94	203	2.10	198	2.01	198	2.09

When all six of the different math courses were so analyzed, the results indicated that three of the four courses at Phoenix and both courses at Alexandria demonstrated an overall significantly positive TICCIT effect upon achievement. In a comparison between TICCIT and programmed instruction, the TICCIT effect was positive and approached accepted limits of significance. That there were fewer items on the posttest common to the two conditions (38 instead of 44) would lead to an expectation of a lower effect than that between TICCIT and lecture. The positive effect was obtained for both day and evening classes.

In those analyses, there are two interactions which should be mentioned. For beginning algebra at Phoenix, the evening division contributed the major effect to the achievement gain, demonstrating a gain equivalent to ten percent of the possible total score. A similar positive effect was found for the day division students at Alexandria.

The ability and content subscores for math posttests were examined in an attempt to discover whether TICCIT might be strong or weak in certain areas of study. Table 3 lists the ability levels and content categories analyzed on the basis of various posttest items. As might be expected, the number of items for each type of ability or category is small. ETS analysis indicated that although some of the subscores did approach reliability for group measures, most did not, making any outcomes more descriptive than conclusive. Few of the categories resulted in significant effects; only two significant effects were repeated across terms, and both were in favor of TICCIT. Solution of routine problems as an ability level involved positive TICCIT effects in every case and significant effects in two courses. The other repeated significant positive effect involved the content category of equations. These specific strengths must be attributed to the depth of coverage of topics and extent of practice capabilities. In general, in those areas of the math curriculum considered to require the highest ability and to be most advanced, TICCIT outcomes showed consistently positive effects.

The topical tests administered and the analysis of the effect of TICCIT are shown in Table 4. Generally, the effects follow the pattern found in posttests. Although only one of the results was significant at acceptable levels, in four of the cases the results show a sizeable point difference which represents a positive TICCIT effect equivalent to ten percent of the total possible score on the tests. Another indication of the positive impact of TICCIT upon achievement is the fact that these results apply to a wider range of students than those taking posttests since the topical tests were administered earlier in the term.

TABLE 3

ABILITY LEVEL

- Factual recall
- Manipulation
- Solution of routine problems
- Demonstration of concept comprehension

CONTENT CATEGORY

1. Arithmetic
2. Algebra
    - (a) Simplifying, including properties of and computations with signed numbers and complex numbers
    - (b) Equations, including substitutions, equivalent equations, solution of equations, and word problems
    - (c) Exponents, radicals, and logarithms
    - (d) Factoring, multiplying, and dividing algebraic expressions including quadratics
    - (e) Number line and coordinate plane
    - (f) Inequalities, absolute value, and sets including solution sets
    - (g) Sequences, arithmetic and geometric progressions
    - (h) Permutations and combinations, binomial theorem

TABLE 4

ACHIEVEMENT RESULTS: ANALYSIS FOR IMMEDIATE LEARNING
Alexandria and Phoenix
Math Courses
Academic Year 1975-76

Course	Term	Topical Test	Number of Students	Multiple Correlation	Independent Variables	Regression Weights	Value of t-statistic
007	Spring Semester	Linear Equations	72	.71	TICCIT(1) Lecture(0)	2.76	3.16**
108	Spring Semester	Algebraic Expressions	47	.60	TICCIT(1) Lecture(0)	2.27	1.42
31	Fall Quarter	Linear Equations	63	.62	TICCIT(1) Lecture(0)	.41	.35
31	Winter Quarter	Linear Equations	47	.63	TICCIT(1) Lecture(0)	2.17	1.83
31	Spring Quarter	Linear Equations	27	.75	TICCIT(1) Lecture(0)	2.61	1.61
32	Spring Quarter	Algebraic Expressions	52	.30	TICCIT(1) Lecture(0)	-2.09	-1.61

**$p < .01$

Results -- English. Only cumulative learning as indicated through posttests was analyzed for achievement effects in English courses. The posttests themselves were divided into two parts. An objective test called for responses to multiple-choice questions about grammar and writing structure; the second part of the test required the students to write an essay on a given topic.

As with completion rates, the results for achievement in English appear much more complicated than those for math, largely because of the entry into the analyses of various interaction terms and seemingly inconsistent results. The initial analysis involved highly mixed results, with six of the ten cases showing negative TICCIT effects. Four of the cases were significant but highly unique: a positive effect on objective scores at Phoenix, a negative effect on objective scores at Alexandria, a positive effect on the essay test at Alexandria, and a negative essay effect at Phoenix. Only analysis combining these data with various interactions makes the result any clearer.

At Phoenix the combined analysis does show a positive impact on achievement based on the objective test, across both terms. In the first term the effect was dependent upon age and did not appear in the initial analysis. The effect was positive and significant at the mean age (26.5) of the students who completed courses on TICCIT. The effect was still positive, though not significant, at one standard deviation below the mean age (18). The second term at Phoenix also demonstrated the same significant, positive effect for TICCIT, though independent of age. Descriptive evidence for a third term demonstrated that the trend continued.

For the essay tests at Phoenix, there was a difference between day and evening division students. A positive TICCIT effect occurred among day students, yet among evening students there was a significant negative effect, probably attributable to the fact that part-time instructors unfamiliar with TICCIT taught the evening divisions.

The significant negative impact on the objective posttest at Alexandria seemed to be related to entrance ability. For very high ability students (pretest scores one standard deviation above mean) the effect became positive; as pretest scores decreased, the negative TICCIT effect increased. The other significant effect at Alexandria was a sizeable positive effect on the essay scores of the TICCIT evening division students. The ETS evaluation attributes some of this gain to the fact that one instructor for the lecture sections stressed writing skills, sacrificing performance on essay tests. That may be true, but it should be pointed out that such a statement might be true of all TICCIT English sections, since the TICCIT course as designed clearly stressed writing skills.

To summarize the achievement data for English, it is necessary to discuss the preceding data in light of one additional fact. That fact is that the TICCIT English courses were used in somewhat different contexts at the two colleges. At Phoenix the courses were used in a manner more closely akin to the original "mainline" concept advocated by developers than they were at Alexandria. At Phoenix, TICCIT classes generally followed the original course outline, meeting an average of once per week as a class; the Alexandria courses could more accurately be labeled "adjunctive," using TICCIT as an additional resource, albeit very important in terms of the proportion of total student time allocated to the system, to the average three hours per week in the classroom. In that light, it can be said that TICCIT as a mainline instructional resource had a consistently significant, positive impact upon student achievement on the objective posttest of writing skills. Other effects noted for TICCIT were often tied to other variables, primarily differential instructor effects. An adjunctive use of TICCIT appeared to have a negative impact on achievement upon all but higher ability students.

Summary. TICCIT exerts a significant and positive impact upon student achievement. For five out of the six observed math courses significant positive results occurred, often resulting in TICCIT posttest scores at least ten percent higher than lecture, corresponding to two-thirds of a standard deviation. In addition to overall higher achievement on posttests, TICCIT promoted higher achievement in the ability of students to solve routine problems and was equal to lecture in promoting adequate performance in the most advanced content areas of the math curriculum. In four of the six math courses, students in TICCIT courses scored about ten percent higher on topical tests of immediate learning than similar lecture students. In English, the only consistent results for courses comparing TICCIT as designed and lecture likewise demonstrated significant positive effects for TICCIT students, resulting in an estimated difference of five percent in scores on objective tests of writing skills. Except where inexperienced instructors affected results, TICCIT students also scored higher in essay tests.

COURSE COMPLETION RATES

Student completion rates among the various TICCIT applications varies tremendously. There does not appear to be any simple explanation for the variations, but one of the most obvious factors is the environment in which the TICCIT student learns. Because of the self-paced nature of the TICCIT system, the effect of instructor involvement in the learning environment appears to have an even greater impact upon completion than originally thought.

In the original community college implementation, there was no emphasis upon completion as a program outcome; however, early in the demonstration it became apparent that high completion rates would not be achieved without a more structured environment. Therefore, the TICCIT users at BYU established the use of TICCIT in environments which included a weekly scheduled class meeting, small group discussions, individual student/teacher meetings, and other features designed to motivate the student to complete within the academic term.

This model produced completion rates generally higher than in comparable lecture sections at BYU. In math, the average completion rates for classroom instruction was 65%. Classes taught by one of the TICCIT math authors averaged higher rates than the class room rate. Two classes taught by teachers previously unfamiliar with TICCIT were mixed; one had a completion rate of 72%, the other 33%. Rates for TICCIT English classes were also favorable, ranging from 88% to 96%. Those rates exceeded the very liberally-calculated completion rate of 82% for the classroom (the lecture sections did not include in the rate calculation any of a large number of students withdrawing before the third week of class). Clearly, when efforts are expended to obtain high completion rates, it is possible to do so in an environment which attempts to pace students within certain time periods.

Although community college implementations of TICCIT did not generally include such concerted efforts to increase completion rates, the TICCIT English instructors were generally very imaginative in their approaches to directing the TICCIT classes, using class meetings and group discussions, and it was apparent that those efforts did result in completion rates that, although lower than lecture classes at the community college, were significantly higher than those in math classes in which there was basically no effort to pace student learning according to any schedule. In three of the five cases in English there are significant negative impacts upon completion attributable to the TICCIT condition, but they are all at much lower levels than in math. The rates were generally 10% to 20% lower than classroom completion rates, which ranged from 60% to 75%. The analysis is complicated by the fact that there are several traits exerting some influence on completion and a number of trait-treatment interactions, which, to add to the confusion, often vary when analysis within terms is compared to analysis across terms. Some of the student traits having a significant impact upon completion, regardless of instructional condition, included division of enrollment (in one section, day students had a 45% better chance than evening students of completing an English course), class instructor, and re-enrollment (in three of the five sections, students repeating or continuing a class had a poorer chance of completing than those enrolled for the first time). Contrary to the analysis for math, there was in English some significant interaction between entrance ability as demonstrated on an objective pretest of writing skills and completion rates in TICCIT sections. The interaction did not occur in either tested term at Phoenix College, where TICCIT English was used in a manner more consistent with its original design than at Alexandria, although the term did just reach a significant level upon analysis across both semesters. At Alexandria, where the English courses on TICCIT were used more in connection with additional classroom instruction than originally intended, the interaction appeared in two of the three tested classes, but it did not appear in the analysis across quarters. The interaction indicates that students of very low ability were hindered by TICCIT, but that as entrance ability increases completion chances increase until chances of completing on TICCIT are slightly better than completing a lecture section for the higher ability students in the course.

The math courses at both community colleges were generally implemented without any of the tools discussed above that would tend to motivate pacing within the academic term. Total self-pacing was the rule for math classes; there was no penalty for re-enrolling for the same course in subsequent terms. There appeared to be little or no discussion with individual students concerning the student's learning pace, and there were no group or class discussions. The results of the analysis do show significant treatment effects upon completion. In 10 of the 12 math classes analyzed, significant (at $p < .001$ levels in all but one case) and negative treatment effects were associated with the TICCIT sections; the two remaining sections showed no significant treatment effects. The rates for TICCIT sections were generally about half the size of lecture rates, which were about 40% to 55%. The analysis also indicated that entrance ability was significant in determining completion (regardless of condition) in 10 of the 12 cases. The only student trait found to interact at a significant level with a particular treatment in a math course was student status. That is, for one math course at Phoenix it was found that part-time students on TICCIT were less likely than full-time students to complete the course. There were no other demonstrated trait-treatment interactions, including none between entrance ability and either treatment. An interaction might have been expected between re-enroll status and the TICCIT condition since many students who re-enrolled in TICCIT sections had only to complete course requirements left unfinished from the previous term. However, no such interaction was found, and in the single case where an analysis of the effect of re-enrollment was made, it was found that 17% of the students enrolled in the particular math section for the second time completed within the term compared to a 15% completion rate for students enrolled in the section for the first time.

CONCLUSIONS

The achievement data consistently demonstrate significant and substantial positive gains for TICCIT students in both math and English. The measure of success for TICCIT was to be its impact upon achievement compared to traditional instructional methods. In that light, it must be said that even in its initial operation, TICCIT was highly successful, teaching math and English students better than was done in traditional classes.

Within the ETS evaluation, it was shown that TICCIT English was most successful in bringing about higher achievement gains and completion rates approaching those of lecture classes. Completion rates at the colleges since the evaluation have improved; in fact, the latest figures showed a TICCIT completion rate (72%) higher than lecture classes. Such data together with the very high completion rates and positive achievement data in the more highly managed environment at BYU show that the use of TICCIT has a substantial and positive impact upon instruction.

Similarly, students in TICCIT math classes performed consistently better on course posttests and on topical tests than their counterparts in lecture sections. Although completion rates for the highly managed environment did surpass lecture rates, the rates for TICCIT math classes within the evaluation context were disappointingly low. Completion was not an outcome highly emphasized during the demonstration, but it was expected that the rates would be similar to those in the lecture classes.

An important question is why the rates in math were so much lower than those for English, especially since the design for each of the courses was basically identical. It has already been suggested that the difference in instructor involvement in student management is the reason for the variable rates. Other possible explanations include the failure of TICCIT adequately to serve the needs of lower ability students. Completion in math did seem to be connected to entrance ability. It is not clear, however, whether the reason for that is the particular math courseware or some inherent characteristic of the system itself.

There is some evidence to indicate that the math courseware used in the demonstration did not serve the needs of those students requiring a large amount of remedial help. TICCIT did include substantial amounts of very basic material, and the course was very successful in math courses at both colleges which were the lowest level courses available. But it does appear that there were simply greater student deficiencies in math than had been anticipated. Moreover, time constraints prevented the completion of any formative evaluation of the materials. In other words, the courseware used in the demonstration was first-attempt material. At BYU, evaluators found that 60% of the lessons were inadequate for BYU students. Opinions from the community college instructors also indicated that the tests were generally too difficult, hindering the progress of many students. Many of the lessons and tests have since been revised to improve observed courseware problems, but it is too early to know what effect upon completion the revisions will have.

The explanation for lower completion rates apparently favored by ETS is that the TICCIT system itself may favor students of high ability to the detriment of low ability students. There is indeed evidence that entrance ability is a factor that must be considered in the analysis of completion rates. For nearly every analysis conducted on completion in both math and English, there were very large and significant correlations between completion and entrance ability. In both TICCIT and lecture courses the group of students completing the course had higher pretest means than the group beginning a course. In only one term in one course, the adjunctive use of TICCIT English, was there an actual interaction between entrance ability and completion. It was shown in that instance that the lower the entrance ability the greater the chance became that a student would not finish because of enrollment in a TICCIT class.

The conclusion that TICCIT is perhaps best suited for those of high entrance ability does not appear to be based upon that interaction term from English. The conclusion seems to be based upon the observation of differences in pretest means of students finishing on TICCIT and students finishing lecture sections. The differences in the fall terms were particularly large. However, in later terms the differences in pretest mean scores became much smaller, primarily because of the addition in later terms of the scores of students taking more than one term to complete. The effect of this can be seen in the analysis of the fall term of beginning algebra at Phoenix. The pretest mean for students finishing TICCIT was 44.86 while for lecture it was 41.28. Logically, one might conclude that any difference in posttest scores (actual scores for TICCIT and lecture were 40.06 and 38.82, respectively) must be due to the high entrance ability. However, further analysis limiting the comparison to higher ability students (defined in this case by pretest scores greater than or equal to 35) still showed positive achievement effects. Later analysis eliminating the constraint of completions within a term included a sizeable group of students who had completed TICCIT math during the spring semester. The mean pretest score of this group was 33.92, decidedly below the earlier defined high ability level of 35, below the pretest mean of lecture students completing the fall semester (38.64), and below even the mean of the lecture students from the fall who did not finish within one term but also completed in the spring (34.62). Yet this broadening of the applicable entrance ability did not subtract from the overall achievement result. In fact, as mentioned earlier, the inclusion of all the students requiring more than one term to complete increased the impact of achievement results. Although the view of the TICCIT completion and achievement results *within* a single academic term tends to support an argument for TICCIT suitability only to high ability students, the results across terms weakens the argument with the inclusion of substantial numbers of students with much lower entrance abilities who, nonetheless, add a greater degree of significance to the positive achievement data.

An additional factor which weakens the high entrance capability argument is the topical test analysis. For topical testing, an even broader segment of the student population was included. Unfortunately, no detailed analysis is made of students completing topical tests in terms of entrance ability. The comments in the evaluation imply that the group taking the pretest was more inclusive than the group completing TICCIT but did not include the entire population beginning the course. The students were characterized as those able to make progress towards completion on TICCIT. Again with the enlarged population, there are still substantial achievement gains for TICCIT students in five of the six courses. Although the data is not clear, the implication from the topical test results is that the entrance ability argument must be still further weakened.

The evaluation report's treatment of the topical tests seems to concern itself with the fact that the TICCIT population taking topical tests was still smaller than the population originally enrolling in the course. That fact may in some situations be compelling evidence in support of the contention that TICCIT is better suited to highly capable learners. But the context of this evaluation is a comparison of TICCIT and traditional instruction; therefore, the statement that TICCIT would be suitable only for high ability students implies that the lecture condition has a more positive impact upon those of lower ability. It is clear from evaluation data, however, that the traditional instructional method also exerts a strong bias against the lower ability student. The issue then is not simply whether TICCIT exerts a bias towards low ability students but whether that bias is significantly greater than that already existent in traditional instruction. Without very substantial differences, the statement that TICCIT is suitable for high ability students could not be justified. On the basis of the results of across-term analysis and topical testing discussed above, the developers do not find such differences to justify the conclusion that TICCIT applications should be limited to those involving only highly capable learners.

Further arguments against the general hypothesis that TICCIT is not suitable for students of less than high ability are found in the following observations. First of all, the math courses under consideration were fundamental courses in community colleges with very liberal enrollment policies. A large number of the classes for which data were taken did not qualify as college credit courses but were developmental classes to compensate for pre-college deficiencies. They are necessary and important courses, but it may be difficult to support any general statement concerning high ability students on the basis of observations only from these courses. Perhaps even more interesting is the relationship between two of the courses at Phoenix. Generally, students enroll in math 007 only because they have not demonstrated the entrance ability, as judged by performance on a pretest, required for math 106. By definition, students in 007 would be of lower entrance ability (i.e. lower pretest scores) than those in 106. Yet the analysis for math 007 demonstrated one of the strongest positive effects for TICCIT students.

In short, the developers find in the evaluation satisfying evidence that TICCIT can be successfully applied in learning environments in which there are varied entry abilities. Although entrance ability must be considered in the system's implementation, it is not clear what relationship it does in fact have with completion rates. It would be difficult to prove from the data that there is a causal relationship between entrance ability and completion. It is, of course, possible that some other student trait closely associated with entrance ability, such as general self-motivation capabilities, contributes to the discrepancy in rates. There is, in fact, some evidence within the evaluation to support that contention.

Comparing the completion rates of math to those of the self-paced programmed instruction makes it reasonable to assume that the problem of low completion rates is a generic problem with self-managed instruction. The rates found in TICCIT were comparable to the rates in the self-paced programmed instruction at Alexandria and to the historical rates of similar programs at Phoenix. The evaluation record mentions the problem a number of times, referring, for example, to the fact that many students failed to attend classes regularly, or at all, when pressures from other non-self-paced courses increased. Records of the number of hours spent on-line also indicated that students not completing the course spent fewer hours on the system than the number of hours assigned for classroom usage in the lecture sections. (For example, a study conducted by Alexandria indicated that average usage for students not completing TICCIT sections was approximately 30 hours. The lecture sections met for 50 hours per term.) There is apparently a problem with the management of student progress which greatly contributes to lower completion rates.

The management problem is not surprising, however. From the beginning, the developers understood that such problems existed with self-paced instruction and did attempt to create solutions in advance. The TICCIT math and English courses were both designed to be implemented in an environment in which the instructor took an active role in the management of student progress. The originally defined role of manager-advisor to be assumed by instructors included goal-setting and performance evaluation behaviors. Such a model was implemented much more fully in the English than in the math courses. As has been seen, completion rates in English were higher; in fact, the lowest completion rate in any English course was higher than that for any math section.

The English and math course designs themselves were simply not divergent enough to result in such large completion differences. However, a review of the implementation contexts show striking differences. ETS observed that English instructors took an active role in prescribing study materials, conducting small group discussions about common difficulties, and handling individual student problems. On the other hand, math students had much less instructor contact, and the great majority of contact that did occur was centered on content problems rather than individual progress problems. At Phoenix, students were not even assigned to particular math instructors; consequently, the instructors assigned to the lab in a given hour may not have been able even to identify individual students. In short, there appear to have been substantial differences between both the quantity and quality of instructor interaction with math and English students.

It is perhaps understandable that there were differences between the management efforts in math and English. The developers did attempt to provide features in the system, such as various reports concerning individual student progress, but for various reasons no systematic method of handling the management problem was provided. It is to the credit of the colleges themselves that programs were developed in the English courses that did improve student completion rates through better management. The methods implemented, including small group discussions and closer involvement in individual assignments, could and should also be used in mathematics. The possible impact of management was not discussed in the ETS evaluation of math completion rates, possibly because none of the math sections dealt with the problem and because no obvious solutions to the problem were ever suggested or implemented. But because of the basic similarities between the courses, there is reason to believe that similar management efforts would also increase math completion rates. The evaluation did indicate a strong correlation between time spent on-line and the number of math lessons completed. To improve the rate of completion, it would appear then that measures are needed to improve student motivation to spend an adequate amount of time on the system. Further evidence for the efficacy of management efforts is found in the BYU math implementation, discussed earlier in the completion rates section, in which TICCIT completion rates did exceed those of the classroom.

The developers are highly pleased with the results of the evaluation. Very clearly positive achievement results for instruction in English was a result expected by very few people. Yet the results do show that grammar and composition can be taught systematically with positive effects on student writing capabilities. Even in the initial year of implementation of a radically new instructional method, nearly as many students finished the course with TICCIT as with the established instructional method and performed significantly better on achievement tests. As instructors have become experienced with the system, its effectiveness continues to be manifested: completion rates now often exceed those of the classroom. Achievement for math students on TICCIT is equally pleasing. Distracting slightly from that enthusiasm were the lower completion rates found with the math sections within the evaluation. However, the developers find no reason to believe that there is any inherent characteristic of TICCIT instruction that would prohibit completion in math from being equal to that found with English. There is ample evidence, including already improved completion rates, that the management techniques used to improve completion for English classes are just as effective in promoting completion rates in math comparable to or exceeding those in lecture classes. TICCIT is a very powerful instructional tool, one which should continue to impact the future of educational practices.

REFERENCES

Bunderson, C. Victor. A Rejoinder to the ETS Evaluation of TICCIT, June, 1977. CTRC Technical Report No. 22, Brigham Young University, Provo, Utah.

Evaluation of the TICCIT Computer-Assisted Instructional System at the Community College, National Science Foundation Contract No. NSF-C731, Educational Testing Service, Princeton, New Jersey.

Critical Decisions: An Evaluation of a CAI Evaluation

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The purpose of this presentation is two-fold: (1) to describe the non-standard method that was used to evaluate the various processes and procedures employed by more than 20 PLATO courseware development groups, and (2) to evaluate this method. For ease of presentation, the method is described in the context of the PLATO system. However, it will become obvious later that is has more general application.

The Evaluation Method

Background. When people first started to write lessons for PLATO, they had to do so without the benefit of other people's experience. Computer-assisted instruction (CAI) was a new technology, so there was little or no literature about CAI. PLATO had unique and novel characteristics, so that research in related areas, such as programmed instruction, was not entirely adequate. Further, decisions had to be made not only about instructional design, but also about project organization and management, where there were even fewer guidelines on which to base decisions. Directors could not even anticipate all aspects of planning that would be necessary.

Each courseware development group using the PLATO system is able to enjoy complete autonomy because of the system's flexibility. Each group makes its own decisions about curriculum, educational philosophy, staff selection, group organization and management. Consequently, the groups using PLATO varied widely in the decisions they made. But they were also different in other ways, such as target population and scope of project. These very different groups sometimes made similar decisions about an effective way to

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improve their project. For example, in at least three different cases, the project director hired a senior programmer to serve as a consultant for beginning authors on his staff. The consultant helped them over difficulties much more quickly than they could have done on their own, and lesson development was expedited. Sometimes, when confronted with similar situations, group leaders chose different alternatives. For example, some decided to develop new curricula for CAI while others adapted available materials.

An evaluation of these experiences was needed to serve as a guide for new groups who would be developing PLATO courseware and as an information resource for existing groups. Little information of this kind was available. The papers and reports that had been generated included such varied materials as catalogs of lessons, student performance data, terminal and lesson usage, attitude questionnaires, and sometimes even cost analysis. However, most provided no data about the evolution of project procedures. Those documents which did include some information of this sort tended to be incomplete and were prone to omit decisions or incidents that produced negative results. Sometimes they reported only on the current phase of a project and omitted earlier work. Nor did historical descriptions fulfill the need. They were, perhaps, interesting, but did not separate the significant events from the insignificant. External evaluators reported on some aspects of project development. But, their work was limited to their particular focus (House, 1973; Mahler et al., 1976).

In response to the general need for such procedural information and the particular interest of the Advanced Research Projects Agency in the outcomes of decisions of PLATO projects, an evaluation was designed and implemented.

Purpose. The purpose of the evaluation was to generate a data base for developing guidelines for future projects. It was "....to provide a broad-based set of case histories and decisions that were observed to have specific effects or long-term impact on the smoothness of project implementation." It also was to be "... a first approximation to a taxonomy of factors that should be considered in project management and instructional design" (Steinberg, 1977). Like Walberg's (1973) transactional evaluation, its purpose was to emphasize procedures and processes, rather than end products.

Definitions and criteria. At the suggestion of Allen Avner, the starting point was a paper by Flanagan (1954), entitled, "The critical incident technique." There was a strong parallel between the goals of the PLATO evaluation and Flanagan's work. His purpose was to describe the essential characteristics of the work of air force pilots so that job specifications could be formulated and appropriate training programs developed. (He later extended his work to non-military jobs.) The purpose of the PLATO evaluation was to describe essential decisions that were made in the evolution of courseware development in order to produce management and instructional design guidelines. Flanagan defined an incident as critical if its purpose was clear and the results definite enough to "...leave little doubt concerning its effects." His technique was to gather the facts, classify the incidents by inductive reasoning, and infer practical procedures. Flanagan reported some selective bias due to faulty memories, varied perspectives depending on the role of the observer, and some lack of objectivity.

Although Flanagan's technique was an appropriate beginning for the PLATO evaluation study, its definition and scope were too narrow to encompass all aspects of PLATO courseware development. In addition to observable incidents, non-observable events, such as decisions, frequently played a fundamental role in project achievements. Therefore, I broadened the definition to include decisions as well as incidents. Moreover, there were other kinds of events that met the goals of the study but which were not encompassed by this narrow criterion. For example, specific effects or results in some PLATO projects could be attributed to the absence of a decision. A success or failure was sometimes observed to be a consequence of the decision that a project leader made when faced with several choices. There were instances of success which were the result of an evolutionary process or series of events, rather than a single incident.

Thus four criteria were established and an incident or decision was included in the evaluation if it met at least one of them:

1. the circumstances surrounding a decision or incident were clear, and the effects definite;
2. the project results could be traced to the fact that a leader had failed to make a particular decision;
3. situations in which a choice that was made between alternatives ultimately had a decided advantage or disadvantage; and
4. a scheme or decision that was successful, and had evolved over time through repeated iterations of situation-decision-effect cycles.

Resources. There were three sources of information. The first was my own personal accounts and those of six colleagues, Allen Avner, Eileen Call-Himwich, Larry Francis, Alec Himwich, Joseph Klecka, and Lynn Misselt. The PLATO experience of the group members varied from four to 16 years and included just about every phase of project development, such as lesson writing, author training, observing, consulting, interviewing personnel and evaluation. Each had participated in one or more projects with diverse student populations and subject matter. The second source was the result of interviews with twelve other staff, representing nine additional projects and different levels of responsibility. Twenty papers and reports constituted the third source of information about the projects studied.

Procedure. The initial thrust was a series of informal meetings with my six colleagues. Case histories which came to mind immediately were discussed. This initial set of incidents provided a basis for formulating the definitions and criteria noted above. The incidents were then classified, and this in turn led to an outline of categories. Once the criteria were defined, and the topics generated, they were used as a guide at subsequent meetings of the group, to clarify earlier case histories and to inspire new ones. I held interviews with staff members of other projects, in groups of two to four people and also reviewed available project reports, reading for critical decisions and incidents. Finally, all of the case histories were screened for meeting the criteria, and then incorporated into the classification scheme. In some instances, new categories were added and the classification reorganized. In those instances where an incident fit equally well in two categories, it was included in both places.

Finally, the findings in each major category were summarized, and background material was written in order to put the results in proper perspective. This was done because some of the results may have seemed to be nothing more than common sense. But what may be obvious in hindsight was not so clear or even visible in foresight.

Product. The evaluation product is a report with three major features. First, it contains more than 125 case histories of critical decisions or incidents. Each history includes not only the decision or incident, but the circumstances surrounding it, and its effect. Where applicable, an epilog describes subsequent events. An example is Case 2A1.3, under the general topic of instructor acceptance and cooperation.

> "In one large curriculum project the director decided to put curriculum management under computer control. That is, the computer kept a complete record for each student and on that basis decided which lesson to present next. The instructors were unfamiliar with the lessons and the hardware. Although they had the option of overriding the computer and setting up their own sequence, they rarely exercised it. They viewed the CBE materials as a separate entity and not an integral part of the regular curriculum.
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> Epilog. In subsequent years, the decision was made to abandon computer management and to give that responsibility to the instructors. By that time they were more familiar with both the lessons and the system. They had to do much more work, diagnosing and prescribing lessons for each student. However, it gave them a sense of power and control over the machine, and they had more students do more lessons than in previous years. The students, in turn, were more interested because the lessons were more appropriate and the teacher showed a vital interest and participated actively." (Steinberg, 1977, p. 6)

The second feature of the report is that the table of contents is effectively a taxonomy of topics that are the subjects of critical decisions in the implementation of CAI. They cover a wide range of considerations, such as introducing CAI to an institution that will use it, selection of courseware development staff, the director's role, models of organization, lesson design, use of peripheral equipment, implementation and integration of CAI, evaluation and maintenance. Finally, the report summarizes and analyzes the processes and procedures that led to successful, unsuccessful, or equivocal results.

Evaluation of the Critical Decisions Method

Limitations. A number of the limitations of the Flanagan method were also foreseen for the present one. It was possible to partially compensate for these anticipated problems. First is the problem of case history accuracy. It is well known that people differ in their perspectives of a situation and in their reports. For example, I recall visiting the classroom of one of my children along with some other parents. Comparing impressions as we left the room, I commented that the teacher was very skillful at individualizing the instruction. She had set up four or five science activity centers and allowed the children to choose the one they would work at. The other mother's reaction was that the teacher was terrible, because the children were not quiet and there was some noise in the classroom. Care was taken to minimize this kind of bias in the case histories by obtaining accounts of the same event from more than one source wherever possible: from individuals who had different responsibilities, or from a participant and an observer, or an external report and an active participant.

A second difficulty with the method as implemented here is that it was done after the fact. The problem here is that memory is selective. People sometimes forget the circumstances that led to a decision. They may recall the more dramatic events and forget the ordinary, or those that had a negative effect. This bias, too, was partially overcome by the procedure of obtaining multiple accounts of a single incident. The structured interviews were of some help too. For example, if other sources had only turned up one case to elucidate a topic, such as how PLATO was introduced to the institution, the interviewees were asked specifically to try to recall events related to that topic.

A third difficulty was that the sample of projects may not have been representative. The study was executed after some of the projects had ended and their staff had dispersed. Case histories of these earlier, or smaller projects may not have been adequately represented.

Time. The evaluation took about half of my time for at least six months. Some of the circumstances surrounding the decisions were extremely complex and required repeated interviews to probe for the exact information that was relevant to the observed result. Weekly group meetings with my colleagues absorbed a considerable number of person-hours. But they had the advantage of jogging people's memories of critical events and providing a forum for thrashing out differences of opinion about what really happened and accurately reconstructing the incidents. Early sessions were unstructured and some of the incidents and decisions they produced were later omitted from the evaluation report because they did not meet the criteria. Subsequent meetings were patterned after the interviews with other staff, and produced more explicit information and a greater proportion of suitable incidents.

Advantages. There were at least three important contributions that derived from this evaluation approach. First is generalizability. An analysis of several similar situations should provide a more reliable basis for decision making than a single event. Furthermore, the documentation of the context in which the events occurred enables the reader to decide whether the results might be applicable in his case. The credibility is highest where both positive and negative instances are available. For example, when PLATO was first introduced to an institution, it was enthusiastically received in cases where special efforts were made to engender good will and to orient instructors; but when no such effort was made, there was some resistance.

The report also provides a vehicle for transmitting experience, from one group to another, as well as to novices. Although meetings can be, and have been held to exchange information, the proceedings are not always recorded for written dissemination, and the information is usually not so well organized as in an evaluation.

Finally, in a relatively new field, it is not always possible to anticipate the kinds of decisions that will have to be made or matters that will have to be considered. The results of this study enable the leader of a new project to plan more accurately, and therefore to implement a more efficient program than would otherwise be possible.

Suggestion for improvement. Bias due to selective representation and distorted memory can be further overcome if critical decisions are documented during planning and development as well as after a program has been completely implemented. Obviously, it is not always possible to anticipate which decisions will be critical and which will have direct long term impact. Nevertheless, I propose some categories as a guide. Edwards and his colleagues (1975) note four sources of change that take place as a program develops: changes in program objectives, changes in program character, changes in the societal or educational needs that spawned the program, and changes that result from the accumulation of knowledge and experience. These sources of change can represent an initial set of topics for documenting decisions and incidents and the circumstances surrounding them at the time they occur. Descriptions of incidents should have multiple authors, to represent different perspectives.

Utilization. Francis (1977) drew heavily on this report to write a management manual to guide directors of CAI sites. An instructional design manual by Call-Himwich and Steinberg (1977) also used the report as a resource. The critical decisions report was published so recently that it is too soon, at the time of this writing, to know how extensively it is being used by others, and who is using it.

References

Call-Himwich, E. & Steinberg, E. R. *Myth and reality: Essential decisions in computer-based instructional design*. Urbana, IL.: University of Illinois, Computer-based Education Research Laboratory, 1977.

Edwards, W., Guttentag, M., & Snapper, K. A decision-theoretic approach to evaluating research. In M. Guttentag & E. Streuning (Eds.), *Handbook of evaluation research* (Vol. 1). Beverly Hills, Ca.: Sage Publications, 1975.

Flanagan, J. C. The critical incident technique. *Psychological Bulletin*, 1954, *51*, 327-358.

Francis, L. *Guidelines for establishing and managing a computer-based education site*. Urbana, IL.: University of Illinois, Computer-based Education Research Laboratory, 1977.

House, E. R. *The politics of educational innovation*. Berkeley: McCutchan Publishing, 1974.

Mahler, W. A. Misselt, A. L., Schell, R. M. & Alderman, D. L. *PLATO Courseware Development Procedures*. Princeton, N.J.: Educational Testing Service, 1976.

Steinberg, E. R., Avner, R. A., Call-Himwich, E., Francis, L., Himwich, H. A., Klecka, J. A. & Misselt, A. L. *Critical incidents in the evolution of PLATO projects, MTC Report No. 12*. Urbana, IL.: University of Illinois, Computer-based Education Research Laboratory, June 1977.

Walberg, H. J. Transactional evaluation in professional education. In R. M. Rippey (Ed.), *Studies in transactional evaluation*. Berkeley, Ca.: McCutchan Publishing, 1973.

A Example of the Application of Cost-Effectiveness Techniques in a Computer-Based Study Management System Evaluation

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Introduction

Most training systems involve compromises in that the resources available for training and education are finite and can usually be expended on some alternative system. This is especially true of computer based instructional systems where resources allocations are large or, at least, are viewed by management as large resource consumers. Because of these resource limitations, it is desirable to examine a number of alternatives to determine how the funds might best be expended. A formal method for accomplishing this goal has evolved from earlier analyses coneucted on allocating water resources. This evaluation, known as cost-effectiveness analysis, is an orderly and systematic means for specifying the worth of alternative methods of meeting the same goal. One of the basic assumptions of cost-effectiveness analysis is that there is no unique solution or set of resources that cannot be utilized in some manner. Most educational institutions are concerned with this allocation of resources, but alternative configurations are usually not considered. The object of an analysis is to provide a set of systematic observations of reasonable alternatives that management can address when considering the selection process. The purpose of this presentation is to consider some of the problems in implementing a cost-effectiveness analysis in training and education and to provide a specific example of an analysis that partially meets the cost-effectiveness analysis requirements.

The specific method under investigation is a computer-based study management system (SMS) that was evaluated in the context of a Navy technical training school. The research was conducted to assess the effectiveness of the SMS and no attempt was made to collect data from alternative delivery systems. This is a common occurrence due to the expense of evaluating more than one system. In many cases the cost is prohibitive, thus the analysis must be done on the basis of projected data and criteria measures that can be compared across systems without the need for physical presence of the equipment. As this was the case with this system, a logical analysis of alternative delivery systems was conducted.

The SMS is really an combination of two concepts, that of questioning techniques interspersed with study assignments as promoted by Rothkopf, (c.f., Rothkopf, 1970) and computer managed instruction (CMI). The concept of querying students to facilitate learning is not new but has received attention recently. The CMI concept provides a vehicle for automating the individualization necessary for effective presentation of the questions. The SMS is designed to maximize student participation in study assignments without requiring extensive revision of existing materials.

SMS Operations

To evaluate the SMS concept in an operational Navy training enviornment, one week of the Interior Communications "A" School was selected as a test vehicle for examining the effects of the SMS. Unfortunately, the week's training could not be completely reformated to maximize the individualized questioning techniques. Instead, the SMS was implemented at the end of the shortened classroom day as a test of the feasibility of the concept. At the end of the conventional instruction period, the students went to a room with eight computer terminals which were used for assessing student knowledge on a number of areas covered during the week's training. When the student felt he had adequately mastered the study material in question, he could request a computer administered quiz. If he could show adequate processing of the information, the student was then allowed to leave school for the rest of the day. If the student could not demonstrate adequate knowledge, he was required to study assignments given him by the computer and return for another questioning session.

Problem Origination

In a sense, the SMS is but one alternative strategy to the conventional instruction; several other strategies could be assessed. However, the question addressed is less broad. In this instance the results showed that a SMS even of limited configuration can provide a suitable alternative form of instruction. When considering the problem of implementing a SMS, the question then becomes which of several alternatives computer configurations can best meet the needs that arise with this specific instructional strategy.

When the research question was initially posed, NPRDC had been developing experimental programs on the PLATO IV system. Thus, the specific computer used in implementing the SMS evaluation was readily available with knowledgeable programmers on hand. Because of these powerful arguments in its favor, it was the obvious choice for this evaluation. However, it is but one of many alternative solutions which are amenable to cost-effectiveness analysis.

Specifying the Alternatives

The PLATO terminal is a sophisticated device that is designed to handle complex graphics displays and extensive computer assisted instructional activities. It is a centrally controlled, remote-site, multiuser system. As such, it has extensive capabilities not essential for SMS operations. Several alternatives could be considered. For this presentation, three types of systems were selected that are representative of the variety of delivery alternatives. One of these is a minicomputer that is used as a stand-alone operation. Another is a time-sharing commercial system which functions similarly to the PLATO system. Both of these alternatives have relatively simple display devices and, in the case of the minicomputer, smaller storage capacity. The other alternative considered is a microprocessor or "personal" computer. While this latter alternative is just now entering the market, their potential is too large to ignore. It probably is less flexible in its delivery modes than the other two systems.

Cost-effectiveness Analysis

Before examining the specific problem, a few comments on the general process are desirable. First, what it isn't: (1) It doesn't provide absolute, firm solutions that void the decision maker's job. Cost-benefit analysis (as opposed to cost-effectiveness analysis) attempts to place dollar values on both costs and benefits to end up with a single value from a numerical ratio. However, many judgements have to be made prior to the determination of the final ratio which can bias the estimate. (2) It does not quantify the unquantifiable. For instance, when the auto industry asks the Department of Transportation to place a value on a human life, the auto industry, in essence, admits it is a difficult to impossible task and does not want to be personally responsible for determining the number. (3) It cannot make a probability into a fixed event. As long as there is some chance of alternative events occurring, estimates of the event occurring must be examined with care.

The cost-effectiveness analysis does provide:

(1) A method for systematically analyzing a number of alternatives that can be evaluated on a number of common criteria.

(2) A method for deriving a cost analyses of all alternatives.

(3) A means for developing descriptive, comparative and/or predictive analyses.

Measures of Effectiveness

Measures of effectiveness are difficult to objectively specify. They can easily bias the results by their wording. It is essential that an adequate number of criteria be chosen without being overly restrictive. Usually their number is limited to seven or eight, at most. In this instance, since the training strategies are not the main point of focus, the criteria were based on the acceptability of various computer configurations for implementing a study management system. They are:

- Student study time
- Student attitudes
- Software development
- Facility requirements
- Hardware requirements

Usually either cost or effectiveness levels are held constant and the other variable is allowed to vary. This may not be a realistic situation but is a goal that is strived for whenever possible. Obviously, it eases the decision-makers job. In this instance, it was possible to select systems that had fairly uniform costs, with one exception. Thus, the decision can be based on effectiveness measures. As stated earlier, it was not possible to actively evaluate all systems due to the resources required. The effectiveness criteria measures were interpolated from the findings on the PLATO system and by logical analysis and interpolation from other known system parameters. All measures are summarized in Table 1 along with the costs.

Insert Table 1 About Here

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1. Student Study Time. In the military training world, student salaries are a direct cost related to training, so any reduction in time can be considered a benefit. The total average time for study and quizzes, excluding study time prior to the first quiz, was 20 minutes. The average time spent on line with the computer was 11 minutes. While there was considerable variability in these times, they can be considered representative of student text processing. In essence, some students completed the material on the first try, while others required repeated efforts to master the material. Whatever the computer system under consideration, the assumption is made that a more flexible SMS approach that allowed the student to access the computer whenever his studies called for it, would result in reduced time to master cognitive information. Although these times were obtained from the PLATO system, from the processing times of the other alternatives, it is felt that no significant increase in computer querying time would be required.

2. Student Attitudes. In general, it was found that students had a slight preference for conventional instruction over computer based questioning and self-study. They judged the specific study assignments useful, but felt the SMS reduced their study independence. No perceived change in study habits was reported. The microcomputer and time-sharing systems should produce similar results, but how the personal system would fare is difficult to project. It conceivably could meet with better reception for two reasons: (a) It isn't preceived as a large amorphous system that has control, and (b) the student could use it at his convenience in a less formal setting. All computer based systems may receive more favorable attitudes if longer exposures were possible. In this experiment, considerable time was necessary to familiarize the student with procedural activities.

3. Software Development. The basic programming requirement is a "driver" lesson that monitors student progress and makes appropriate assignments. For PLATO, which uses a high level author language, this effort required approximately one month of activity by both a programmer and psychologist experienced in other SMS applications. Question generation and entry into the computer was accomplished by a number of individuals, most of which were not experienced in programming. A total time of over 2600 hours was required to complete eight lesson quizzes. The minicomputer along with time-shared system would present a similar require-ment, although the systems communicate in lower level languages, which means a programmer is probably necessary for most work. The smaller personal units rely on languages such as BASIC which is satisfactory for uncomplicated programming applications such as the SMS so that someone who is unfamiliar with the PLATO authoring language probably could develop a BASIC program in approximately equivalent time. The end result is that the cheapest form of software development depends on the expertise of the programmer.

4. Facilities Requirements. The additional requirement is for sufficient floorspace to accommodate a number of computer terminals and study carrels

TABLE 1
SMS DELIVERY DEVICE CAPABILITIES

CHARACTERISTIC	PLATO IV	MINICOMPUTER	COMMERCIAL	MICROPROCESSOR
1. Student Studytime				
a. Potential for reduced studytime.	Very good, fast processing time.	Adequate	Very good	Could be slower than others, depends on demand
2. Study Attitudes				
a. Computer controlled questioning.	Satisfactory, could be viewed more favorably.	Potentially better than PLATO because of local control.	Same as PLATO	Potentially high with high degree of control.
b. Study independence.	Computer controls where & how studies.	Same as PLATO	Same as PLATO	Computer controls how S studies.
3. Software Development				
a. Ease of development	Relatively simple task.	Requires more knowledge than PLATO.	Requires more knowledge than PLATO.	Requires more knowledge than PLATO.
4. Facilities				
a. Floor space	Sufficient for 24 terminals & study correls.	Computer space with suitable air conditioning, 24 terminals and study correls.	24 terminals & study correls.	Space for study correls which would accommodate individual units, or space in S's quarters.

Table 1 - Continued
SMS DELIVERY DEVICE CAPABILITIES

CHARACTERISTIC	PLATO IV	MINICOMPUTER	COMMERCIAL	MICROPROCESSOR
5. Hardware				
a. Display format.	Exceeds any SMS need.	Adequate	Adequate	Adequate
b. Data collection.	Adequate	Adequate for most uses.	Adequate	Limited storage.
c. Independent operation.	Centrally located mainframe, requires phone line data transmission.	Local control.	Out-of-house mainframe, phone lines required.	Controlled by individual, student must learn all operations.
d. Memory availability.	Usually adequate.	Adequate	Adequate	Might need expansion, but feasable.
Discounted annual costs based on a ten year life cycle.	$195,000	$14,000	$16,500	$15,000

necessary for the SMS operation. In the case of the personal system, this additional requirement is not necessary, either the classroom or some distributed set of locations is advisable.

5. Hardware Requirements. As mentioned previously, the PLATO system is designed for large scale operations. The terminals have extensive capabilities that are not essential for SMS operations. Data collection files can be designed, but use relatively large amounts of core storage. Operation requires leased phone lines which can cause operational problems. If the program is large, access to sufficient core may have to be scheduled in advance when large numbers of users are on the system. A time-sharing commerical system operates essentially as does the PLATO system. It involves renting space on a local, variable size system to operate, in this example, user owned terminals. The terminals are those found in stand alone minicomputers which are less flexible than PLATO terminals, but capable of handling all SMS operations. This system has the advantage over a minicomputer of faster operational time, but control of the main frame is in the hands of an outside source. The minicomputer, on the other hand, maintains local control of core usage, but requires all maintenance be planned by the owner. The other alternative is just becoming feasible, so the data is less stable. Hobbyists have demonstrated that the microprocessor configuration is possible at this time, however its feasibility on a large scale is just becoming a reality. The main drawback is a lack of computational power, which translates into longer response time. However, the relatively undemanding nature of most SMS operations reduces the need for large core storage, unless large amounts of data need to be collected. The advantages are portability and individual control over the computer operation. This system could conceivably be operated from any location, such as student quarters. In this case it would be possible to drive an ordinary TV screen, with suitable modifications. Another potential application is to use the microprocessor to drive a videodisc, which in turn drives the TV screen. This latter option provides extensive graphic and animation capabilities.

Cost Considerations

Although it is possible to extract several categories of resourse requirements, to some extent they will remain constant across systems. The major exception is the cost of the hardware systems. To simplify this example, only these costs are presented. These costs have been analyzed in accordance with accepted Department of Defense economic analysis and program evaluation techniques as documented in Secnavinst 7000.19A(1975). This means that the costs for each alternative are specified over the life cycle of the system, in this instance for initial investment and operation. A discount rate of 10% was used to determine life cycle costs. A life span of ten years was used for all three systems. This length of time may be needed to justify the initial hardware costs, yet the equipment may be obsolete before the end of this period. Because this data is difficult to project, the ten year period was arbitrarily selected. All costs are based on the purchase of equipment sufficient to operate 24 terminals on a 40 hour per week basis.

(1) PLATO. To operate this system in San Diego, the following conditions must be met: (a) purchase time on the Control Data Corporation (CDC) timeshare computer in Los Angeles, (b) lease phone lines from Los Angeles to

San Diego, (c) purchase terminals, and (d) contract for maintenance of all equipment. Based on these requirements the initial terminal purchase price is $264,000 and the annual operations budget is $262,800. The annual discounted cost for the ten year life cycle would be $195,000.

(2) Local, Time-share system. This system operates under a slightly different set of requirements: (a) purchase core access time on a locally available large scale system, (b) lease local phone lines, (c) purchase terminals, and (d) contract for maintenance. These requirements can be met with an initial purchase price of approximately $36,000 and an annual operating cost of $20,000. The annual discounted cost is $16,500.

(3) Minicomputer. In this instance, it is necessary to purchase a computer and the peripherials necessary for operation plus provide maintenance for the system. This calls for an initial outlay of approximately $50,000 plus a yearly operation fee of $14,500. The annual discounted cost of this system is $14,000.

(4) Microprocessor. This category is much more difficult to specify because the product is just coming on the market and most manufacturers are not certain about the marketing directions. Obviously, there is a vast potential in the educational area. An example is the newly available Heathkit H.11 computer. A package system with limited memory, video terminal and suitable interfaces retails for $2500 bring the initial capital outlay for 24 stations to $60,000. While it is difficult to estimate maintenance, a figure simular to the minicomputer should approximate the costs, as the Heathkit is partially based on DEC PDP-11 hardware. Thus, the annual discounted cost would be approximately $15,000. This price does not include assembly of the computer and probably does not include adequate memory storage, however it is illustrative of the level of cost involved. Another system just entering the market in Radio Shack's $600 system. This cost is misleading as this system appears to need several additional peripherals for adequate SMS operation.

Final Considerations

The basic premise of this analysis was that comparable systems could be selected that were relatively constant in cost. Examination of Table 1 shows this is true for three of the systems, while PLATO obviously falls into a different category. This is not surprising as the cost-comparable systems were selected with this goal in mind, whereas the PLATO system was used as a demonstration vehicle to examine the feasibility of implementing a SMS without regard to acquisition cost. Obviously, any of the three small systems could conceivably be used, selection is dependent on the training emphasis and the needs of management. The function of the decision maker in this situation is one of weighting the SMS delivery device characteristics in proportion to the needs of the school. For instance, if classroom space is at a premium, the most mobile system would be the likely candidate, in this instance the microprocessor. With the data displayed as in Table 1, management also has the prerogative of equating these outcome measures and taking others into account. It is possible that local availability of a hardware distributor could be important and weigh in the final selection. When the data is displayed in the form of a single number this kind of decision becomes more difficult. The cost-effectiveness tabular display as shown in Table 1 is recommended for maximizing the available information in the most easily interpreted form.

The Many Uses of Evaluation in the Navy's CMI System

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Purpose

Although most large-scale computer-based instructional systems concentrate on providing effective instruction and measuring student achievement, a wide variety of evaluative operations can be performed using the primary data base generated from the basic student-system interactions. Unfortunately, school operators must devote the major portion of their efforts towards ensuring continuous and reliable instructional delivery. The possibilities for fully exploiting the evaluative capabilities of the computer and its data base frequently get lost in the shuffle of keeping the instructional system on-line and in serving the daily needs of the students.

The purpose of this paper is to describe the multiple evaluation techniques which can be applied to one computer based instructional system and the ways in which the data may be used.

In this instance, the Navy's Computer Managed Instruction system will be used as an example to illustrate the applications of various evaluation strategies for solving problems associated with: delivery system effectiveness, course material comparisons, variations of instructional strategies, and the daily management of instructional progress.

CMI System Description

The Navy CMI system consists of a centralized computer facility located in Memphis, Tennessee with schools sited not only in Memphis, but also in Orlando, Florida; Great Lakes, Illinois; and San Diego, California. Presently, the system is managing the instruction for over 6,000 students who are registered in nine schools under the command of the Chief of Naval Technical Training and it is expanding to a projected load of 15,000 students in 24 courses in five locations. This projected student load represents about 28% of the entire Navy technical training school population. Each school is made up of one or more learning centers. All the schools operate on a Keller-like model requiring 100% mastery of criterion referenced tests. Students spend 6 hours per day in a learning center. Although the physical layouts of the learning centers in Navy schools vary from school to school, the same instructional components exist in all centers. Generally, each center is located in a large room with one or more similar clusters or rows of individual study carrels for students to use while studying textual materials, an equipment area for conducting laboratory experiments or practicing with equipment, two testing areas (one for testing of knowledge skills and another for actual performance testing), a central location for the instructor, and an optical scanner and interactive keyboard/printer for communicating with the computer. Auxillary areas for distribution of instructional materials and equipment are located nearby. The knowledge testing area will involve a number of study carrels in which microfiche card readers are installed. The student obtains the appropriate test microfiche card, completes the test at the reader, and then returns the card to the instructor. The study carrels are arranged so that one instructor may manage up to 30 students, although as many as 80 or 90 students may use the OPSCAN and keyboard/printer.

Diagnostic testing of subject-matter deficiencies is, of course conducted in the Navy CMI system. After completing the instruction for a module, the student completes the module test which consists of up to 50 five-alternative multiple-choice items. The answers are entered by the student onto a machine-readable answer sheet and then entered into the computer. After test grading, the computer tells the student which items were missed and makes a remedial study and test assignment. Generally, three forms of each test are available and are randomly assigned to a student to aid in preventing the students from merely learning tests and passing the answers to other students. The data are stored within the central computer located in Memphis. It is the function of various software programs to summarize the data and provide what data outputs are necessary to facilitate instruction either by aiding the instructor, the schools, the CMI system manager, or the developers of instructional materials.

For this paper, representative data will be displayed which illustrate the uses of student data which facilitates the functioning of an operational computer-based instructional system. The uses will be described on the basis of who actually uses the information for decision-making activities: the instructor, the schools, the system managers, or the instructional material developer.

Data Uses

One of the primary uses of data in the Navy CMI system is to facilitate the instructional progress of the students. This is accomplished through a Student Progress Report (SPR) which is provided on a daily basis to each instructor. A sample of the SPR is presented in Table 1. The reader is not expected to understand what every column represents without a lengthy explanation, however, it is instructive to describe a few of the columns.

The SPR lists the daily status of all the students in one learning center who are under the instructional control of a particular instructor. In addition to the students names there are codes to represent the particular job rating for which the student is working (CDP), the pattern of modules the student is assigned to (PAT), and the current instructional module the student is studying (MOD). The actual hours spent in module is indicated by the (THM) figure and the predicted number of hours (PHM) by the number immediately below the actual hours. The predicted number of hours for a module is determined using pretraining aptitude test scores, the number of years of civilian education, and the student's actual age as predictor variables. This prediction of instructional progress is extremely important, since many of the instructor's actions are based on a comparison of the actual time spent studying against the predicted study time. For example, if the student falls behind his

TABLE 1

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PLEX G02363101   DATE: 27 SEP 77            DAILY CMI STUDENT PROGRESS REPORT         COURSE: 045               PROGRESS REVIEW
L/C E HPS=5.0    TIME: 07:21
                             ***CURRENT MOD*** ******************PERFORMANCE THRU LAST MODULE*******************  P L L I A D E M
SSN/SCN       RR        CDP  MOD  AHM  THM PTC   ADD    AL  ADJCT PROG  REQ ***LEARNING RATE / PROGRESS RATE**  G 7 2 N P P X O
NAME                    PAT       LHM  PHM CAL   LOST   PL   PCT         ADD  -6   -5   -4   -3   -2   -1   LM   R M M C R R T D

508-82-4392 61          6260 007   0    9   5     0     46    81    3+   .0  .50 2.08 1.39 1.21  .93  .97  .93 : :D: : : : : :M
SAGERT PAUL D            B         5    7  19     0     49    87             .50 2.08 1.39 1.21  .93  .97  .93 : :D: : : : : :

179-54-8849 55          6262 006   0    6  13     1     42   114    5+   .0  .00  .63  .60  .57  .58  .92  .90 : : : : : : : :
PITT JOSEPH E            A         0   18  18     5     46   126             .00  .63  .60  .57  .58  .91  .89 : : : : : : : :

441-66-1245 55          6262 011   3   22   4    11    112   154    5-  1.3 1.16 1.15 1.17 1.14 1.13 1.13 1.16 : : : : : : : :
PRICE ALBERT             A         2   21  38     0     97   133            1.05 1.05 1.06 1.01  .99  .99 1.04 : : : : : : : :

155-49-2626 61          6260 004   0    1   8     0      9    47    7+   .0  .00  .00  .00  .66  .73  .54  .54 : : : : : : : :
HALL LEWIS H             B         0   15   5     0     16    88             .00  .00  .00  .66  .73  .54  .54 : : : : : : : :

366-72-3791 61          6260 005   1    2  16     2     45   127    5-  1.2  .00  .00  .60 1.83 1.44 1.15 1.18 : : : : : : : :
GRAFT JAMES A            B         0    6  14     0     38   108             .00  .00  .60 1.83 1.44 1.15 1.12 : : : : : : : :

316-65-9106 61          6263 006   0   10   6     0     29    89   14+   .0  .00  .37  .70  .58  .58  .62  .67 : : : : : : : :M
MILLS KEITH A            B         0   15  14     5     43   103             .00  .37  .70  .58  .58  .62  .67 : : : : : : : :

303-56-3030 61          6260 010   0    0   5     0     69    94    7+   .0  .63  .86  .97  .96  .89  .87  .90 : :D: : : : : :
KIRK DOUG E              E         0   12  21     0     76   104             .63  .86  .97  .96  .89  .87  .90 : :D: : : : : :

412-98-7561 55          6262 006   0   12   8     2     30    81   18+   .0  .00  .28  .66  .70  .62  .66  .64 : : : : : : : :M
WEAVER WILLIA            A         0   17  13     0     46   127             .00  .28  .66  .70  .62  .61  .60 : : : : : : : :

205-38-5344 55          6262 000   0    0   0     0      0     0         .0  .00  .00  .00  .00  .00  .00  .00 : : : : : : : :
RENSHAW CRAIG            A         0    0   1     0      0     0             .00  .00  .00  .00  .00  .00  .00 : : : : : : : :

452-15-4139 61          6262 012   0    2   3     4    117   134    5-  1.4 1.09  .99  .97 1.03 1.07 1.06 1.07 :3: : : : : : :
PEREZ EMILIO             E         0   10  36     7    109   125            1.02  .95  .92  .99 1.04 1.03 1.04 : : : : : : : :

459-70-0201 57          6261 003   0    2  10     0      7    59    9+   .0  .00  .00  .00  .00  .28  .72  .60 : : :I: : : : :M
CUNDIFF MICHA            A         0    3   5     0     12    98             .00  .00  .00  .00  .28  .72  .60 : : :I: : : : :

497-70-1252 55          6262 006   0    2  10     1     33    85   15+   .0  .00  .51  .48  .50  .54  .59  .64 : : :D: : : : :
GRIFFIN JEFF             A         0   16  12     0     46   125             .00  .51  .48  .50  .52  .57  .67 : : :D: : : : :

357-56-5957 55          6262 011   0   13   4     5     95   129    9+   .0  .88  .88  .98  .96  .98  .98  .96 : : : : : : : :
[illegible] FRANK        A         0   21  32     0     99   134             .84  .85  .95  .90  .92  .92  .90 : : : : : : : :

258-17-4212 61          6260 001   0    1   0     0      1     0         .0  .00  .00  .00  .00  .00  .00  .00 :0: : : : : : :M
[illegible]TSON STE      C         0    6   1     0      1   104             .00  .00  .00  .00  .00  .00  .00 : : : : : : : :

13/L7? I=12? D=10 /L2? I=05% D=05%/INC 75%COMP G=5C8 ?=33 /APP= ?DAYS/DPP=30%/EXT=RADD V2.0 M3.0 R4.0=DF? X=30% Y=10%/MOD=     HPS
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predicted completion time, the computer generates the amount of extra study time (REQ ADD) the student would have to spend every day in order to complete the course at the original predicted time. Other information tells the instructor how the student did in the seven previous modules via the learning rate (LEARNING RATE) information. Learning rate is literally a comparison of the ratio of actual over predicted number of hours studying. Hence, a number over 1.00 indicates a student took longer than the predicted time. By comparing these learning rates across a series of modules, represented under the figures -6, -5, -4, -3, etc., the instructor can detect a trend in the student's study behavior. The columns at the right side of the SPR are flags to alert the instructor to various events. For example, the PGR column indicates when the student has 3, 2, or 1 modules remaining before completing the course. The instructor can take certain administrative actions to expedite the student's transfer. Criteria for these various flags are set by each school.

These SPRs are quite important to the instructors as it is the only way the instructor can determine that a student is progressing adequately when "passing" a test based on 100% mastery and the students are progressing at their own rate. What is also patently necessary is that the initial predicted completion times be accurately determined for each individual student. Obviously, any deviation from the "real" expected time for completion witll either penalize the student by setting too rapid a completion rate or will penalize the school by setting too lenient a standard. It is a research function to continually monitor the prediction equations and improve the predictive capability of the system.

The schools may use the SPRs but generally do only in those cases where a student has been brought before an academic review board. At some point, set by the school, the slow student will be attrited from the school for inadequate performance. When making this decision the school review board will actually obtain from the computer a Response History File which describes in detail the progress of the student, including every response to all test questions. (Including an illustration in this paper of a Response History File would be a waste of space, but be assured that all student information is available.)

Other data uses are made by the school in terms of general record keeping. There are standard printouts which will list summary information about school graduates or school attrites. These summaries include listing individual students, their aptitude level, total hours in course, predicted time in course and prospective job assignment code.

The CMI system manager also uses these summary sheets for each school for making system evaluations. The system manager can also request special test data summaries to compare schools during certain time periods or for certain kinds of students, high or low mental level, for example, Generally, the system manager would not be using the Response History File or the Student Progress Report. It should be noted that the system manager is responsible for making any changes in any of these reports so that office does has an obligation to keep informed of its effectiveness and recommend changes.

Instructional materials developers have a need for data in order to revise materials or tests. To satisfy this need the CMI system has an Item Analysis program which can provide summary item data for any test. A sample of the Item Analysis report is presented as Table 2. Again, time and space dictate against a detailed explanation, but some information is obvious. For each item, it is possible to determine how many students responded with each of the response alternatives, the P-value or percent correct, and the number of students missing the item on the basis of students who scored high or low. From table 2 it is apparent that certain items in this particular test are in need of change. All of the other data summaries are also available to the materials developers and they use that information for making constructive changes.

The research community has access to the data through the CMI system manager. In fact, it is a major responsibility of the investigators to be responsive to the needs of the Navy CMI system manager. Accordingly, it is the researchers responsibility to make accurate use of the available data in order to make valid recommendations for system changes. A recent instance of the research use of data involves the comparison of two similar courses and their effects on a subsequent non-individualized course. In this case, it was necessary to extract data from the CMI system and correlate it with data from non-CMI school data. By doing this, it was possible to inform the CMI system manager of the comparative benefits of the two CMI courses with the effects on the subsequent follow-on training.

Ideally, all of the training data would be accessible from the same computer data base and the difficulty of combining computer data with non-computer data could be avoided. That task is also part of the research community's function and will be undertaken in the following year.

Conclusion

Organizations using computer-based instructional systems should optimize the data handling fucntion of the computer by establishing a multiplicity of evaluation procedures within the computer itself. These procedures can be used not only to aid in individual student achievement such as the student Progress Report in Navy CMI, but also to provide system administrators the summary evaluations which they need for making revisions in course materials, tests, or media delivery options. Ideally, the integration of system instructional objectives with appropriate evaluation procedures would occur prior to acquisition of the computer system and would result in well-defined and planned operational procedures for using the wealth of data that are stored in any computer-based instructional system. With the computers technology now available, there is no excuse for not using the information.

In our research organization (NPRDC) like many of you, we are faced with attempting to change an existing system and adding data-base management functions. Although difficult, this is an important task, since data management is the one function that the computer can most supremely facilitiate and thereby support its own continued existence in an instructional context.

TABLE 2

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                         CMI RESPONSE HISTORY -- ITEM ANALYSIS -- TEST:ITEM #  1003

 T.  #      N  #MISSES  #ANS 1  #ANS 2  #ANS 3  #ANS 4  #ANS 5   CORR LO-WRONG HI-WRONG P-VALUE    DIST.      SKEW

     1    376      47       6       2     329      20      19     3       19        9  0.875-9900.000     24.100
     2    377       5     372       3       2                     1        3        0  0.996  100.000      4.700
     3    377       3       2       1     374                     3        2        0  0.992-9900.000      3.100
     4    377      10       7     367       1               2     2        3        1  0.973-9900.000      4.100
     5    377      44      16     333      16       5       7     2       12        5  0.983-9900.000     15.700
     6    377      13     364       4       8       1             1       10        0  0.965  100.000     15.800
     7    377      13               3     364       8       2     3        6        1  0.965  100.000      8.900
     8    376      19       1                     357      18     4       14        0  0.949-9900.000     22.200
     9    377      15       3       3     362       1       8     3       10        0  0.960-9900.000     15.900
    10    377      11     366       5       2               4     1        7        1  0.970  100.000     10.500
    11    377      12     365       6       1               5     1        6        0  0.968  100.000      9.500
    12    377      35       2       3      17     342      13     4       22        3  0.907-9900.000     32.900
    13    377      33       1     344       9      12      12     2       17        0  0.912-9900.000     26.900
    14    377      34              31     343       1       2     3       20        2  0.909  100.000     30.400
    15    377      11       4       1     366       1       5     3        5        0  0.970-9900.000      7.900
    16    377      71     306       2      57              12     1       25        6  0.811  100.000     35.600
    17    377      12      10       2     365                     3        6        0  0.968-9900.000      9.500
    18    377      1[illegible]       8      10     359                     3       10        0  0.952-9900.000     15.800
    19    377      17       3      14     360                     3       11        0  0.954-9900.000     17.400
    20    377      24     353      23       1                     1       16        0  0.936  100.000     25.300
    21    376      24      24     352                             2       15        0  0.936-9900.000     23.600
    22    375 [illegible]      53      42      80     195      15     4       50       43  0.4[illegible]3-9900.000     50.300
    23    377      3[illegible]     345      18       9       5             1       14        0  0.915  100.000     22.200
    24    377      4[illegible]      54     317       1                     2       27        0  0.840-9900.000     42.800
[illegible]    377 [illegible] [illegible] [illegible]       6               1     1       30        1  0.819  100.000     47.000
[illegible]    376      1[illegible]       4     [illegible]41       4       1       4     2       11        0  0.960-9900.000     17.400
[illegible]    377 [illegible]               1     371       3       2     3        4        0  0.946  100.000      6.300
[illegible]    377      21       5              12     354       4     4       13        1  0.944-9900.000     2[illegible].[illegible]00
[illegible]    377      4[illegible]       1      41       1     334             4       19        0  0.885-9900.000     30.100
[illegible]    377      5[illegible]       2       2     322      1[illegible]      41     3       24        1  0.[illegible]54-9900.000     4[illegible].600
[illegible]    376 [illegible]       3     367       1       1       4     2        8        0  0.976-9900.000     12.600
[illegible]    376 [illegible]       4     367               3             2        7        0  0.[illegible]1-9900.000     11.100

          [illegible] LO [illegible] P.          HI CUTOF HI POP.          AVG. TIME P-VALUE LO [illegible] HI MEAN EXAM [illegible]

 [illegible]    377      27      63              51     14[illegible]               1.0     .91[illegible]  24.777   31.500    2[illegible].[illegible]1
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Improving Language Skills by Computer

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There has been a steady decline in the language abilities of our population. Along with this decline come the editorials regarding the high school students who cannot read, the legislators who cannot write, and its composite impact on our society. And rightfully so. Of all the skills children are taught, most of us would probably agree that reading is the most essential, enabling skill for them to acquire. But as reading proficiency declines, so does writing ability. Today, one is likely to speak more in a week than write in a lifetime. Functional illiterates who cannot even write their own names may suffer embarrassment, but somehow they manage to subsist in our technological society. Those functional illiterates who cannot read street signs or follow simple directions, however, are so severely handicapped that it is questionable whether they can survive, much less thrive, in our society. A recent U.S. Office of Education study revealed that 22 percent of American adults do not have sufficient reading skills to effectively cope with daily life. The market for language improvement is large and probably growing.

Within the Navy, reading and writing skills are widely used in school and job settings. The use of these skills appears to increase in the more technical or data-oriented schools. A recent study showed that reading problems were experienced by 20 percent of students in Class A schools, 15 percent of persons in recruit training, and 15 percent of those performing on the job (Sticht, Fox, Hauke, and Zapf, 1977). A recent survey of entering recruits showed that 7.5 percent were reading below the 6'th grade level (Duffy, 1976). Compared to the average enlisted population, poor readers tend to have higher discharge rates, experience more difficulty in training, and perform less satisfactorily on the job. In the Navy, as in the nation, there is a need to improve language skills.

In an embryonic way, the computer is beginning to serve as an evaluator and instructor of language skills. It has yet to find its place, but we know that it belongs. This paper reviews and illustrates what the computer offers the field of language arts. Although the paper centers around reading skills and the computer, writing skills will also be considered. Several programs under development at the Navy Personnel Research and Development Center in San Diego will be highlighted.

Reading and the Computer

Reading has often been regarded as a coordination of various subskills which become automatized with practice (LaBerge and Samuels, 1974). Whether reading should be taught by a subskill approach or as a holistic process, however, is debated by educators (cf. Samuels, 1976; Smith, 1971). Whichever the preference, either approach can be implemented on the computer, and this will be demonstrated. Before elaborating on this, two other features of the computer-as-reading-instructor should be mentioned. First, the computer has a knack for motivating. Motivation is especially important for the illiterate adult

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frustrated from previous attempts at learning to read. The patience of the computer is welcomed. Second, the computer has the capacity for individualizing instruction. Because of the intricacies of language and the unique linguistic experiences of its learners, the individualization feature becomes increasingly important. The instructor must adapt to the learner, and the computer does this well.

I have been working on a computer-assisted instruction project for remedial readers (below a 6'th grade reading level) from the Naval Training Center in San Diego. The computer system is a Digital Electronic Corporation PDP-11/45. The computer drives our multi-media system (MMS) learning stations. The MMS is is an on-line, instructional research facility providing state-of-the-art audio and video technology for lesson presentation and data collection. Critical to the reading program are the video cartridge player, audio cassette player, and digital voice synthesizer. (For a complete description of MMS, see Wisher,1977). Four MMS-equipped stations are available, and each may be used independently from the others.

Consider first how a subskills approach to reading instruction can be implemented. Our program includes three skill areas: phonics, vocabulary development, and comprehension. The phonics course drills the student on vowels, vowel blends, word beginnings and endings, homonyms, homographs, silent letters, synonyms, and antonyms. Each of these phonic units is further divided into a multitude of instructional units, and each unit is introduced by a computer-controlled, video tape lecture. There are twenty-five such lectures, each between 1 and 2 minutes in duration. Not only are they of instructional value, but they also serve as a diversion from the drill routines. The student is drilled on the phonic unit by seeing, hearing (via the voice synthesizer), and saying groups of words which share a particular sound. The course of instruction encourages substantial student-computer interaction; the student is free to have any word repeated via the synthesizer as many times as is desired. The response history from these interactions provides insights into the self-imposed remedial habits of the student.

Altogether, a corpus of several thousand words is presented in well-defined instructional units. Considerable time is spent quizzing the student on the current unit. If the student fails a quiz, the video lecture is repeated and a new set of drill words follows. Approximately 15 hours of instruction, distributed over 5 days, are available.

The vocabulary and comprehension skills area is incorporated in what we call reading theater. Reading theater operates in the following manner: the student views a video segment of actors engaged in a particular task , accompanied by an audio dialogue. The dialogue is instructional in nature, and is written at a level appropriate to the target population's reading ability. Occasionally, a special effects generator superimposes text on the monitor. Again, the video segments, text superimposition, and any response collection are under full computer control. A critical assumption of reading theater is that seeing and hearing an enactment summons comprehension. With de facto comprehension, instruction can then relate a written description to that which is already understood. The instruction extends accessibility to that knowledge rather than impose a new organization on it.

The role of the computer in reading theater is critical. Since the computer controls the video player, it can do so on the basis of a student's response. This occurs in the following manner: At various points in the play, the video halts but continues to display the superimposed text and waits for the student to respond. The superimposed text might be the dialogue or it might be a quiz about the video enactment, such as a cloze type test, word recognition probes, sentence completion tasks, or dialogue paraphrasings. Unlike many other strategies for teaching vocabulary and comprehension, reading theater begins with what is understood and traces that representation to a written form. Importantly, feedback to the superimposed textual material is immediate and can influence the course of instruction. For example, suppose the word " wrath" is used and graphically enacted during the play. The student might later be quizzed on the meaning of wrath; if correct, synonyms could be displayed and pronounced by a computer-controlled audio cassette, but if incorrect the segment with the enactment of wrath could be re-displayed. Vocabulary development occurs in this manner.

A similar approach to the skill of reading comprehension is available. At strategic points, the video stops and a comprehension question is displayed. Presumably the student comprehends the video but does not necessarily comprehend the written question or its four alternate anwers. If the students responds incorrectly, the appropriate video portion is redisplayed and the question is reworded. If correct, either a second question appears or the video continues. Note that both literal and inferential questions may be asked. Note also that the reading theater concept may be extended for many other instructional purposes.

The Computer and Reading-as-a-Holistic-Process

In addition to the subskills approach to teaching reading, a holistic approach to reading instruction is also available. A program called CAR (Computer-Assisted Reading) unobtrusively monitors reading progress while instructing the student. CAR displays text in a self-paced, sentence-by-sentence manner. The displayed sentence has a number of words underlined, each with a number beneath it. By pressing the appropriate number key, the student can have any underlined word pronounced by the voice synthesizer. Soon to be available is a word-meaning request facility: the student presses the shift key and the number of the underlined word - the voice synthesizer gives a definition of the word in the context in which it appears. The pronunciations and definitions are immediate.

Comprehension can be monitored by interrupting the sentence-by-sentence routine with a comprehension question and a choice of answers. If the answer is incorrect, the appropriate sentence or sentences that contain the answer are redisplayed. Interestingly, one can test for comprehension immediately or have a number of sentences intervene before the question appears. Since the number of words per sentence and the reading time are recorded, a sentence-by-sentence printout of reading rate is available.

Writing and the Computer

It is unlikely that the computer will ever approach the adeptness of a skilled writing instructor. Writing is a creative, generative process of composing and revising, all in a natural language. But the computer's ability to process natural language is very limited. Because of this restriction, one cannot simply type a paragraph into a computer and receive a printout of commentary as insightful as that of a writing instructor. On the other hand, the computer offers assistance in teaching various aspects of writing which are fundamental to sound composition.

Perhaps the greatest impact the computer will have on writing instruction stems from the organizational requirements of prose and the processing capacity of the computer. The organization, or disorganization, of a sentence or paragraph can readily be manipulated by a computer. When this manipulation is managed by the student but guided by various instructional objectives, the proper development of a written body unfolds, and the student plays a generative role in its development. Before providing some examples, let me discuss some hardware and software preferences for a computer-as-writing-instructor. A display screen is necessary and a rapid baud rate, 2400 or greater, is desired. Since text is continually manipulated, revised, or deleted diring the course of instruction, teletype printout soon becomes cumbersome. For the same reason, a programming language well-suited to string manipulation is desirable, such as SNOBOL. In some operating systems, the editor includes powerful manipulatory features, such as the editor in the UNIX system (Ritchie and Thompson, 1974).

I have been developing a writing-improvement program on our multi-media system. The program includes sentence-combining and paragraph-organization routines. The sentence-combining routine displays various phrases, each with a corresponding number, on a screen. The student's task is to combine the phrases in various ways so as to form a meaningful sentence. This is accomplished by pressing a sequence of number keys - the created sentence is displayed immediately. This routine graphically illustrates how phrases can be combined to form clauses, and how clauses combine to form sentences. At times, the computer can request that a sentence with a particular style be created, such as one beginning with a dependent clause and having a modal auxiliary to the main verb. Since the various number sequences which form such a sentence can be stored beforehand, the student can be given immediate feedback on the appropriateness of a response. Such sentence combining activities have proved to be effective in improving writing skills (O'Hare, 1973). Unlike normal classroom instruction, the computer can immediately rearrange the phrases, display them in a readable format, and provide feedback.

The paragraph-organization routine operates in a similar manner; instead of rearranging phrases into a sentence, one rearranges sentences into a paragraph. For example, six sentences might be listed on the screeen, each with a corresponding number. The student's first task is to identify the topic sentence, and then specify the order in which the sentences are to be arranged. The sentences then appear in paragraph form, but may be rearranged at the student's discretion. This allows the student to read the newly created paragraph, judge its "semantic flow", and make necessary revisions. Furthermore, the computer can request where the topic sentence be positioned, or it can request that a short sentence precede the topic sentence and so forth.

The student may be allowed to write and insert one sentence or to delete the sentence that is considered least important. Such exercises help to develop an understanding of the organizational structure of a paragraph as well as an appreciation for its style. The effectiveness of such instruction rests on the computers ability to update and redisplay the "working paragraph" immediately in contrast to the turnaround time typical in a classroom setting.

Final Comments

Both the subskills and holistic approaches to reading instruction have been implemented and are being evaluated against a regular classroom setting for remedial readers. The writing project is in development but a timetable has yet to be established for testing its effectiveness. In addition to these instructional routines, many traditional language assessment procedures can readily be implemented on the computer, such as reading comprehension and vocabulary tests. The computer, then, offers the language arts field a versatile device for evaluating and improving language skills. Reading can be taught by various approaches and classroom writing instruction can be supplemented with writing exercises. The impact the computer can have on impriving language skills has yet to be appreciated.

References

Duffy, T.M. 1976. Literacy research in the Navy. In T.G. Sticht and D.W. Zapf (Eds.), Reading and readability research in the armed services. Alexandria, Va:Human Resources Research Organization.

LaBerge, D. and Samuels, S.J. 1974. Toward a theory of automatic information processing in reading. Cognitive Psychology 6 293-323

O'Hare, F. 1973. Sentence combining: improving student writing without formal grammar instruction. National Council of Teachers of English, Research Report No. 15, Urbana, IL

Ritchie, D. and Thompson, K. 1974. The UNIX time sharing system. Communications of the Association for Computer Machinery, July 1974

Samuels, S.J. 1976. Heirarchical subskills in reading acquisition. In J.T. Guthrie (Ed.) Aspects of reading acquisition. Baltimore: The Johns Hopkins University Press.

Smith, F. 1971. Understanding reading. New York: Holt, Rinehart, and Winston

Sticht, T.G.,Fox, L.C.,Hauke,R.N., and Zapf, D.W. The role of reading in the Navy. Technical Report 77-40. Navy Personnel Research and Development Center, San Diego, Ca.

Wisher,R.A. An on-line multi-media laboratory for instructional research. Manuscript submitted for pulbication, November, 1977

The Effects of Drill Structure
on Learning in Phonetics Lessons

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ABSTRACT

This study is undertaken to investigate the advantages and disadvantages of different forms of drills as used in CAI lessons in phonetic transcription. Measurements of student learning, student attitude and time required for completion are considered for drills constructed 1) with and 2) without specific rehearsal of items initially missed. Time spent by students in exploratory and quiz sections of the lessons is also recorded. Recommendations are made for other similar applications.

BACKGROUND

PLATO lessons in the teaching of phonetics have been used at the University of Illinois and elsewhere for over four years. Students typically begin the course in general phonetics with one lesson which serves both to familiarize students with the study of the symbols of the International Phonetic Alphabet (IPA) used for the transcription of English and to acquaint them with interacting with PLATO in a simple drill format.

Next, concurrently with lectures about the nature of speech sounds, they use the set of lessons in transcription (primarily drill and practice), with which this study is concerned. For the next several weeks, these lessons replace regularly scheduled laboratory practice sections in transcription. They require students to type the phonetic symbols representing the particular sounds which are presented to them by means of an EIS random-access audio device in conjunction with a PLATO terminal.

At other appropriate points later in the course, additional drill, simulation and game lessons are provided as a supplement to lecture and laboratory sessions.

METHOD

For this study, two forms of the transcription lessons were constructed. Both took advantage of natural groupings of the sounds. (Consonants were presented first, those with symbols which closely resemble letters being followed by eight with less familiar or less intuitive symbols. Ten common pure vowels were studied next, followed by a group of ten common diphthongs.) For each group of new sounds, a period of exploratory study came first; students heard the sounds while being presented with the respective symbols, and could ask PLATO to repeat an individual sound or the entire sequence. When ready, they proceeded to a drill on the sounds under study. Return to the exploratory section was available from the drill. Students were required to master each group before going on to the next, but could review previous groups at any time.

In one version (A) of the drill, each item was selected at random from the pool of items under study. Students worked from that pool until they had successfully identified twelve of the last fourteen consecutive sounds on their first attempt. No special attention, other than providing diagnostic feedback and requiring the correct response before continuing, was given to items missed.

In the other version (B), students worked through the same set of items ordered randomly, then were required to repeat any items that were confused until these were correctly identified on initial presentation. Sounds that the student transcribed incorrectly, as well as the stimulus sound on which errors were made, were restored to the pool of items retained for further rehearsal. The student was required to continue practice within the set until he/she missed fewer than two items on the first try.

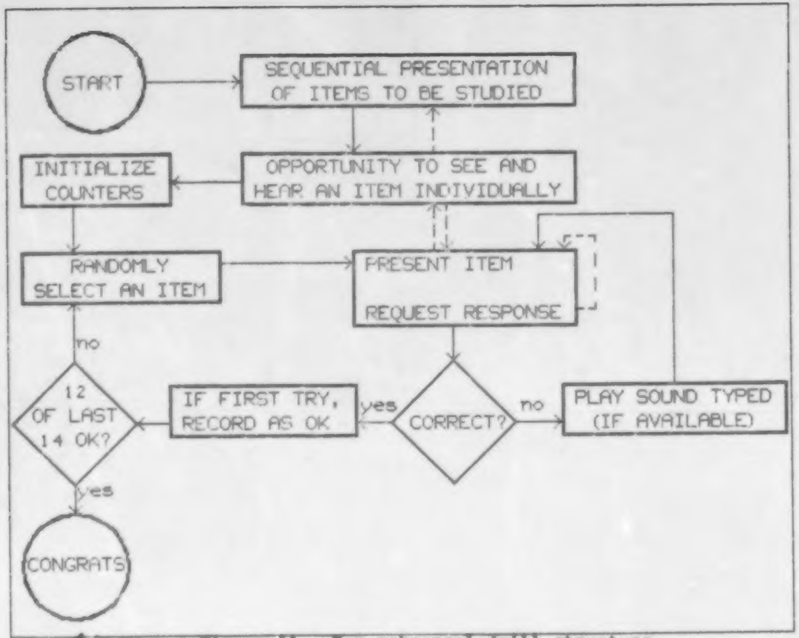
START
SEQUENTIAL PRESENTATION OF ITEMS TO BE STUDIED
INITIALIZE COUNTERS
OPPORTUNITY TO SEE AND HEAR AN ITEM INDIVIDUALLY
RANDOMLY SELECT AN ITEM
PRESENT ITEM
REQUEST RESPONSE
no
12 OF LAST 14 OK?
IF FIRST TRY, RECORD AS OK
yes
CORRECT?
no
PLAY SOUND TYPED (IF AVAILABLE)
yes
CONGRATS

Figure 1A. Non-rehearsal drill structure

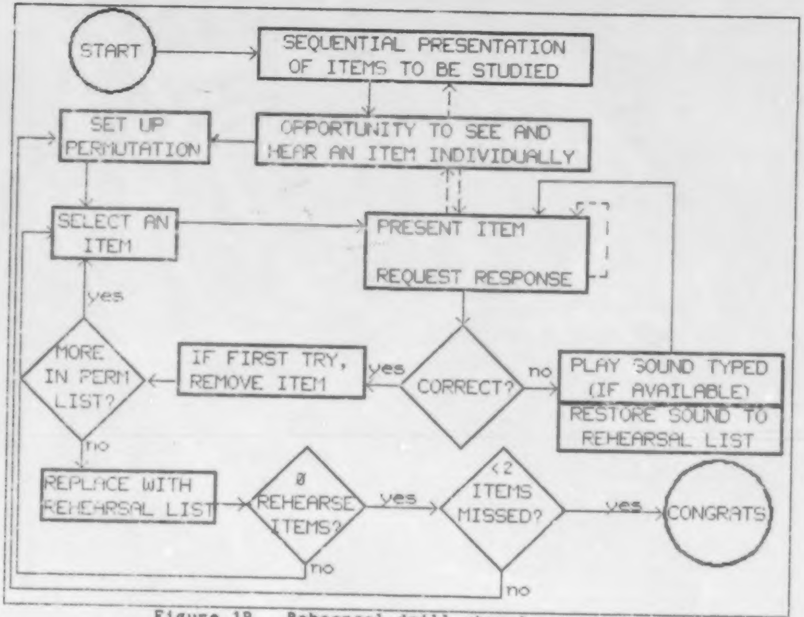
START
SEQUENTIAL PRESENTATION OF ITEMS TO BE STUDIED
SET UP PERMUTATION
OPPORTUNITY TO SEE AND HEAR AN ITEM INDIVIDUALLY
SELECT AN ITEM
PRESENT ITEM
REQUEST RESPONSE
yes
MORE IN PERM LIST?
IF FIRST TRY, REMOVE ITEM
yes
CORRECT?
no
PLAY SOUND TYPED (IF AVAILABLE)
RESTORE SOUND TO REHEARSAL LIST
no
REPLACE WITH REHEARSAL LIST
0 REHEARSE ITEMS?
yes
<2 ITEMS MISSED?
yes
CONGRATS
no
no

Figure 18. Rehearsal drill structure

Schematic diagrams of a sample structure for one group of sounds as studied within each version are shown in Figure 1.

Subjects were the students in SPSHS 301, a course in general phonetics at the University of Illinois, Urbana. Enrollment was fairly evenly distributed among juniors through graduate students, and the course was a requirement for about three quarters of the students, because of academic major.

Preliminary data were collected on 18 students during the spring semester of 1977, during which half of the class saw a rehearsal and half saw a non-rehearsal form of the lesson. During this run, rehearsal was limited to only the stimuli which were incorrectly identified, rather than restoring the incorrect sounds typed for them to the rehearsal list as well. The groups were matched on the basis of previous background in phonetics, attitude toward PLATO instruction based either on previous experience or hearsay, and academic major. Results of the study were assessed by an off-line quiz in transcription and an informal attitude survey given to both groups after students had completed the lessons.

Additional data were collected on 26 students during the fall semester of 1977. In addition to studying achievement differences between students who studied different versions of the lessons as structured in Figure 1, we took a survey on student attitudes both before and after working through the lessons. How much time the students spent in the exploratory and quiz sections of the lessons was also recorded.

Proficiency in transcription was measured at the conclusion of the three weeks during which the lessons had been completed by administering an off-line audiotaped dictation test, which both groups took concurrently. The test was evaluated by a grader who had no knowledge of which students were in which groups.

Attitudes toward PLATO instruction were assessed by asking students to respond to the statements, "PLATO is a useful mode of instruction," and "PLATO is an enjoyable way to learn," by indicating either strongly unfavorable, unfavorable, no opinion, favorable, or strongly favorable. The attitude test was administered immediately after the students had taken the dictation test.

Data on performance were evaluated by *t*-tests. Attitude data were analyzed by ranks, considering the responses to each question to contain at least ordinal information. Data on time spent were examined for relevant correlations with attitude and performance measurements both between groups and within groups.

RESULTS

Data from the preliminary study indicated that students using the form of the lesson with rehearsal (even rehearsal without restoration of incorrectly typed sounds to the rehearsal list) were significantly ($p<.05$) better at transcription, though both had learned the material adequately. Results of an informal attitude study in the preliminary test yielded no significant differences between the groups; all were on the neutral to positive side.

Again in the fall study, both groups seemed to master the material presented. The number of errors on the transcription quiz ranged from 0 to 7.5. Within group A, the mean number of errors was 4.46, and the standard deviation was 1.82. Within group B, the mean number of errors was 2.81, and the standard deviation was 2.19. The difference between groups was significant ($p=.047$).

Students' attitudes toward using PLATO were generally favorable, slightly more being favorable after they had completed the lessons than before. Asked a general question about whether, given a choice, they would choose to use PLATO in the course for learning basic, essential skills, rather than doing so in small quiz sections, 17 of 26 said they'd choose PLATO at the beginning of the course. (Five from group A and four from group B would prefer quiz sections.) A few students shifted within each group for a final small change to 21 of 26 choosing PLATO. (Three from group A and two from group B opted for quiz sections.) Thus, the choice of drill structure was not shown to be a significant factor in influencing decisions on whether PLATO should be used.

Student opinions on whether PLATO is useful as a mode of instruction are summarized in Table 1. Both groups were slightly favorable to PLATO initially, and both improved by the conclusion of the study. Among possible comparisons, however, only the change from before to after within group B was found to be significant at the $p<.05$ level. Though a pro-PLATO shift was observed and found significant, results as to whether group differences exist are inconclusive.

Group	Before lessons					After lessons				
	SU	U	-	F	SF	SU	U	-	F	SF
A	0	1	3	7	2	0	0	0	6	7
B	0	1	5	3	4	0	0	0	1	12

Table 1. Comparison of attitudes toward usefulness of PLATO: number of respondents in each category.

Similar results occurred on whether PLATO was thought to be an enjoyable way to learn. Table 2 shows a summary of students' responses. Again, the shift was generally and significantly favorable to PLATO, the only individual comparison reaching significance ($p<.05$) being group B, before and after. It can be concluded that these students were favorable toward PLATO as an enjoyable way to learn, and were more strongly so after completing these lessons.

Group	Before lessons					After lessons				
	SU	U	-	F	SF	SU	U	-	F	SF
A	0	1	6	4	2	0	1	2	8	2
B	0	2	5	5	1	0	0	1	3	9

Table 2. Comparison of attitudes toward whether PLATO is an enjoyable way to learn: number of respondents in each category.

On the average, people in group B took longer to complete the lesson portions under study, as shown in Table 3. Partially because of the wide spread in both groups, however, the difference was not significant. Students spent about 18% of their time in the self-directed exploratory sections of the lessons.

Group	Exploratory	Quiz
A	6.3 / 3.3	36.7 / 22.9
B	9.7 / 8.5	50.1 / 29.9

Table 3. Means / standard deviations of times in minutes spent in exploratory and quiz sections of the lessons.

No substantial correlation was found among achievement scores, time spent and student attitude within either group. A difference in approaches was noted from student to student in frequency of exercising the option to return to the exploratory section for review. Some students, on reaching the quiz, elected to stay there until PLATO moved them on; others reviewed their choices as many as seven times within one set of items. Again, however, this difference in approach did not correlate with achievement scores.

CONCLUSION

This study affirms that programming lessons to train the students by providing extra practice on their problem areas is educationally sound, and indicates that the extra time involved in the lesson design is worthwhile in terms of student learning and attitude. Further evidence of the value of such constructs in CAI languages is thus provided. Other questions remain open for further study, e.g., whether rehearsal of incorrectly typed items is important to include as well as the stimulus for which they were typed.

In addition, we have begun to gain a better understanding of the strategies of sophisticated learners in an environment allowing a learner-controlled mix of self-directed practice and drill.

The study itself provides an example of a benefit of linked users in a CAI network. Designed, programmed and analyzed at the University of Delaware, the study's administration took place entirely at the University of Illinois. Without such a common workbench as was provided by the PLATO system and its varied communication schemes, it could not have been executed.

Finally, we have demonstrated that there is much to be learned by studying instructional variations within CAI materials. In addition to the important tasks of validating lessons and comparing instructional media, we hope that users of CAI will continue to take advantage of the flexibility of the computer for the study of the many options available to lesson designers and programmers, viewing our system as perhaps the most powerful educational research tool ever developed.

ACKNOWLEDGEMENT

The authors wish to express appreciation to Tamar Weaver and other system and PEER group members for their help in using the datafile, area analysis package and statistics programs.

On-line Data in CBE

by

Tamar A. Weaver

Introduction

The use of CBE allows us to collect data on the student's interaction with lesson materials in as much detail as we want. It is unreasonable to collect full data for a large number of subjects because of space limitations.

Summaries of student interactions in the lessons were collected for a large number of students. The purpose here is to show that measurement of performance and difficulty in lessons can be derived from the data summaries.

The objectives were:

a. Find ways to use on line data for CBE lesson development and evaluation.

b. Find correlation with off-line data.

c. Find limitations in the use of on-line data.

Procedure

Lessons in mathematics, biology, accounting and chemistry, were given on PLATO to community college and some high school students.

Measures like percent of questions answered correctly on the first try or ratio of wrong answers to the number of questions, were computed for each student.

These measurement were compared among the classes that studied the same lessons. Observation in classes helped in judging whether the data were reasonable.

This research was supported in part by National Science Foundation contract US NSF c-723, and by the Advanced Research Projects agency of the Department of Defense under U.S. Army contract DAH c-15-73-c-0077 I want to thank the people that helped in data collection and in editing this paper: Larry Francis, Esther Steinberg, Charles Weaver, R.A. Avner, Lynn Misselt, Keith Bailey, Lou DiBello and Barabara Lederman.

Lessons that showed low performance were changed and the new data were looked at to find a reflection of these changes. Graphic representations of various lesson and student data were generated to help in the comparison.

Off-line test scores were correlated with on line data and stepwise multiple regression performed.

The tools on PLATO IV

The projects involved used the available on-line data machinery on PLATO. These data are summaries of what the student has done in a lesson or parts of it: number of questions presented, number of questions answered correctly on the first try, number of anticipated wrong answers , number of unanticipated wrong answers, number of HELP or branching requests that got the help and number of HELP requests that weren't satisfied. This together with the time it took were collected for each student. A lesson part for which the data is summarized in one summary is called an "area", and therefore the on-line data summaries also called the "area data".

Interpretation of the On Line Data

From the raw data, two main measures were computed. The measure of lesson difficulty was the number of wrong answers per question (no/question) and the measure for smooth and good performance was the percent of questions answered correctly on the first try (okf%).

Comparison of the results in many classes with the instructors' reports and our own classroom observations of lesson difficulty led to a table of standard ranges for these two main measurements. The percent of questions answered correctly on the first try was found to be lower than 70% where there were problems, and higher than 80% when the class was working smoothly without special difficulties.

When an area was hard, the ratio of wrong answers per question was not necessarily high. However, when this ratio was high, a real problem was always present.
In practice areas or in trial and error type of instruction, these limits are not relevant.

For each lesson or area (part of a lesson) a normal range of the data was found by taking means for all the classes that used it. These numbers were used later for estimating the match of a lesson to a certain course that used the lesson later on.

Evaluation of Lesson Revisions

The measurements derived from the on-line data in lessons were sensitive to changes in the lessons, and clearly reflected the changes (mainly by the percent of correct answers on first try). The okf% was higher when an improvement was made, and stayed the same when the lesson was not changed. In one case, when a clearly bad change was made, the data reflected decrease in the performance measure as you can see in the next example.

An Example of How the Data Reflects Revisions of a Lesson*

The main instructional part of a math lesson teaching the addition and subtraction of signed numbers was divided into seven areas. Each of the first six areas contained instructions, examples, and exercises dealing with one type of problem. The seventh area provided mixed practice with the previous six problem types. Data for several classes are found in Table 1.

The lesson was first used by over one hundred community college students in Spring 1975. As anticipated by the authors, the difficulty of the fifth and sixth areas (subtracting with negatives) was greater than that of other areas. The final mixed exercise showed more difficulty than expected. In five of the six classes the %okfirst dropped off dramatically for the mixed exercise (the seventh area). You can see that for classes B and C of Table 1, but not for class A.

These data suggested a need to add an additional "help" area before mixing together all six types of problems. Because individual problem types were apparently mastered, the additional part was constructed to teach discrimination between the problem types.

The question was who should have to do this help area. An examination of the histograms of percent ok on first try for each area provided additional insight about what was happening to the students. Figure 1 presents the results of a representative class for the last three areas of the lesson. These and class A of Table 1 suggest that many students apparently did well throughout the lesson whereas a few of the students plummeted rather suddenly on the last mixed exercise. This information, combined with analyses of individual students, led the author to decide that only students

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* This example was presented in more detail in a project report "Analysis of Student Data in Computer-based Education" by Tamar a. Weaver and Larry Francis.

Table 1

Class Means in the Signed Number Areas Before Revision

	Area	Min/use	Min/stu	%Okfirst	Errors/ques
Class A	1	2.0	2.3	87	0.40
	2	1.4	1.6	88	0.21
	3	1.7	1.9	88	0.16
	4	1.1	1.2	88	0.22
	5	2.6	2.9	80	0.45
	6	1.6	1.7	78	0.32
	mixed	2.0	2.1	82	0.31
Class B	1	1.4	1.7	85	0.10
	2	1.5	1.8	77	0.35
	3	1.4	1.8	90	0.15
	4	0.9	1.0	88	0.14
	5	2.5	2.7	78	0.35
	6	1.7	1.8	81	0.30
	mixed	2.1	3.2	70	0.48
Class C	1	3.8	5.9	76	0.74
	2	2.3	3.1	78	0.32
	3	2.5	3.2	86	0.16
	4	1.8	2.1	86	0.29
	5	4.7	5.7	70	0.84
	6	4.0	4.6	62	0.56
	mixed	5.1	6.2	56	0.51

who scored lower than 80% on the previous areas would be routed through the additional discrimination exercise (i.e., the "help" area).

A second, simultaneous modification to this lesson was based on instructor requests rather than student data or comments. In order to reduce the time needed for the lesson, the number of examples in each area was reduced from two to one.

These two changes provided the second version of the lesson.

A comparison between the results of the Spring 75, and Fall 75 classes for the first and second versions of the lesson are shown in Figure 2. The classes using the revised version had a uniformly lower performance (as measured by %okfirst).

The reduction in the number of examples was strongly implicated as the reason for the lower performance. These undesirable results suggested that it should be changed back to the original number of examples, and even more in areas that seemed harder.

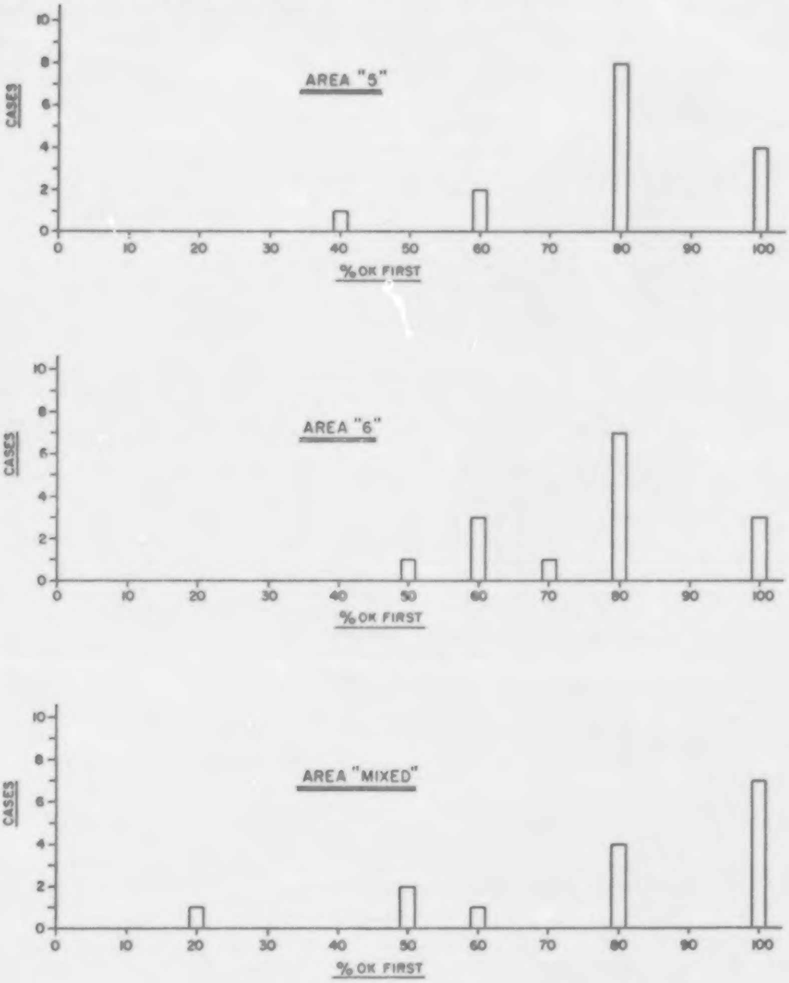
Therefore, one or more examples were added back into all teaching areas except area 4, in which students had scored higher than 80% okf for the revised lesson. Student-by-student analyses indicated the "help" section seemed to be aiding poor students as was intended in spite of the general lower performance.

The data for the third version were collected in Fall 1976. The data from the first two versions were collected from the community college classes, whereas the data from the third version were gathered from junior high school students. Nevertheless, the results of the analysis suggest the lesson behaved similarly for all three groups of students (Figure 2).

The examples added to the third version seem to have raised the %okfirst for all areas except area 4. The fact that the number of examples in area 4 was not changed confirms the validity of the changes to other areas. It is interesting to note that although the %okfirst for this last version is generally lower than that of the first version, the performance on the final mixed test is higher. This is probably due to the "help" area, which was not available to students taking the original form of the lesson. The %okfirst for the help area is lower than all other areas because only students doing poorly in previous sections are routed through

Figure 1

Frequency for Different Okf% in Three Areas Before Revision

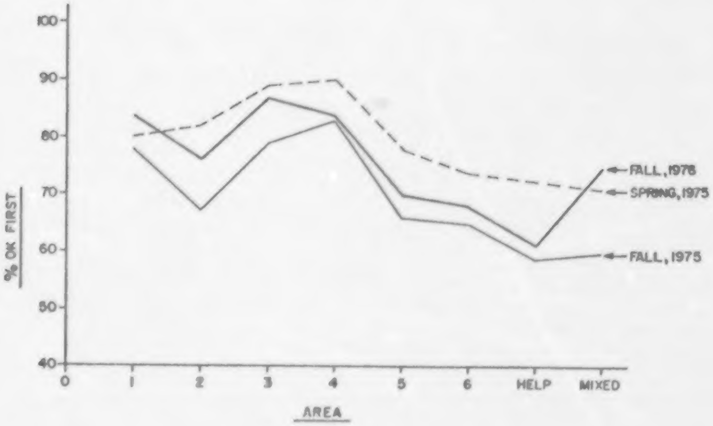


the help area. This extra help and practice in discrimination of problem types tends to keep the poorer students from "falling apart" on the final mixed exercise. The result is that the average score for the whole class, rather than slowly declining through the later areas, makes a sharp upward turn in the final test area. The class average of %okfirst on the final test area is near the average %okfirst of the previous six areas. This is where one would expect it to be if the difficulty with discrimination of problem types had been eliminated since the test samples items from each of the previous areas.

To summarize the example, the few changes in the lesson were very well detected by the student data, and what wasn't changed (area 4) yielded unchanged data.

This example demonstrates how the on-line data reflects very well changes in a lesson and is a good tool for evaluation of such changes.

Figure 2
Comparison between different versions of a lesson



Analysis of Performance Measurements

Any data from an area summary may be transferred to a more powerful set of statistical analysis routines available on the PLATO system. After transfer, the chosen variables can be used in multiple regression routines. Other student data not found in area summaries (like test results) may also be entered in the regression.

Many stepwise multiple regressions were performed to predict test results using on-line data variables as predictors. Three measurements were used: the percent of questions answered correctly on the first try (the variable name in the tables ends with "ok" or %), the wrong answers per question (the variable name ends with "no" or "n") and the time in the area (the varible name ends with "t"). Examples of regression results can be seen in Tables 3, 4 and 5.

The questions asked were which of the area variables will enter in which cases, and which areas will enter for each test.

The expected result was that the "ok" variables would enter with positive contribution to predict test results in a subject relevant to the lesson, the "no" ratio variables would enter with negative contribution to the test results, and the time* would also enter negatively since better students can work through the materials faster. In general, all these things happened.

The way the variables entered in the regression suggests the meaning of these measurements. The okf% (ok on first try) entered considereably in the relevant lessons to predict the test results on the same topic. So the okf% variable may be a good measure for the understanding of specific material.

When the data from irrelevant lesson were checked as predictors to a test, the measurements that were most useful were time and no's per question (both with negative contribution). So these measures may represent general abilities in the field. See Table 2 for examples of such cases.

The few cases where the time or the no per question entered the regression positively , were in practice areas, where the student could practice more if he wanted. The more he practiced, the better he knew the material.

In general, data from lesson that teach material involved in a test, were found to be better predictors of these test results than data from irrelevant lesson. Also, tests on specific skills were better predicted than tests with mixed topics.

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* Further time data study was done by K. K. Tatsuoka and M. Tatsuoka.

Table 2

Examples of the Regression Tables for Two Tests

```
Criterion Variable              20 test2
Residual Variance                54.767   Degree of Freedom
Residual Standard Deviation      7.400    Regression      2
Standard Error of Mean           1.795    Error          14
Multiple R                       0.799    F-Value        12.322
Squared Multiple R               0.638
Corrected R for shrinkage        0.614
Variable Entered                   5
Constant(intercept)             48.47

  Variable-name     B-coef    STD error     Beta-coef    STD error
                              of  B                      of Beta
   5 frfbn          -3.230     1.756        -0.322        0.175
  12 frfct          -2.102     0.598        -0.615        0.175
```

```
Criterion Variable              19 test1
Residual Variance                25.095    Degree of Freedom
Residual Standard Deviation       5.0095   Regression      2
Standard Error of Mean            1.2524   Error          13
Multiple R                        0.8043   F-Value        11.905
Squared Multiple R                0.6468
Corrected R for shrinkage         0.6216
Variable Entered                    5
Constant(intercept)              36.47

  Variable-name     B-coef    STD error     Beta-coef    STD error
                              of  B                      of Beta
   5 snbbn          -3.005     1.445        -0.351        0.169
  10 dsnet          -3.796     0.983        -0.652        0.169
```

Note. The variables are described in the previous page.

Examples of regressions for off line tests with the data

In a math 111 class, signed number lessons data were checked as predictors for test results in a few subjects. See test list* at the end of this section.

Test6, which included signed number questions, was predicted very well by okf% in a multiplication of signed number lesson and negatively by no/question in an addition and subtraction of signed numbers lesson (R^2=.883;SR^2=.874;$F_{2,13}$=48.845; N=16). These two measures were good predictors for many of the tests. (SR^2 for shrinkage.)

Test3 covered fractions with signed numbers. It was predicted by the signed numbers areas with R^2=.777;SR^2=.761;$F_{2,13}$=22.677

In Table 2 there are two examples where the test was not on the subject of the lesson involved: test2, on signed numbers, is predicted by the fraction lesson, and test 1, on set theory, predicted by the signed number data. In both cases the variables that contributed were the time in an area, and the no per question in another area (the time is a significant contributor in both but the no's per arrow is not significant contributor in one of the examples). So the combination of these two variables must be good predictors for general abilty in the field rather than for the specific skill. This was repeated in Biology course (Table 5) where a regression for test2 with irrelevant lessons, while test1 (Table 4) is relevant to this same lesson and involved the okf%.

In a chemistry 121 class some math lessons were given on PLATO, along with a lesson about gas laws. In general it turned out that the results of off-line tests containing materials taught by specific PLATO lesson areas were best predicted using area data from those areas. Data from indirectly related lesson areas entered less strongly , and data from irrelevant areas did not appear in the regression at a significant level.

In Test6, which was on gas laws, the most significant predictors were the data from the gas laws lesson. (R^2=.812, $F_{2,8}$=17.317; p=0.001) The most important variables were the number of no's per arrow in one area, and the % ok on first try in another area of the gas lesson.

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* The test data were provided by the Community Colleges of Chicago PLATO project. I want to thank the director of the project, Dr. Chris Dimas, and the instructors, Walter Chamot, Roger Garst, Jane Guagliardo, Glenn Weller, Robert Bator, Jerum Landway, Eddie Ingersol, Lilian Questiaux, Eugene Costabile, Charles Matz, Ruey-Rong Lii.

Test1 did not include questions on gases but rather on mathematics, and its results were not predicted well by the gas lesson data. (For the same variables $R^2=.420$, $F_{2,8}=2.892$; $p>0.05$)

Test2 fell somewhere in between. It was about units of measurement, and was treated indirectly by the PLATO math and gas law lessons. Regressions were made, first using the gas law lesson data and then the math lesson data. The results were between those of test 1 and test 6. For the gas laws data: $R^2=.701$, $F_{2,8}=9.4$; for the math lesson data $R^2=.538$, $F_{1,12}=13.952$, $p=.003$)

Regressions were also made, using data from the PLATO lessons to predict performance on irrelevant tests and none of the data entered into the regressions at a significant level.

Another example where practice or review time contribute positively is in a military mechanics training course with on-line tests. The time in test was predicted with main contribution from no/q in an area of the same lesson, and time in 5 other areas, one of them was a review area, and it entered negatively. ($R^2=.990$; $SR^2=.989$; $F_{6,28}=486$)

An example from a chemistry 201 course test where the time contributes positivly is a drill in solutions where the student chooses how many exercises he will do (Tables 3).

The off-line tests in the regression examples

In math 111 class:

Test1: Set theory
Test2: Signed Numbers, Graphs, Notations.
Test3: Fractions
Test4: Powers, Polynomial expressions
Test5: Solving Equations
Test6: Signed Numbers, Fractions, Powers, First degree equations and Set theory

Chemistry 121 tests:

Test1: Mathematics
Test2: Units of measurement
Test3: Atomic structure
Test4: Chemical Bonds
Test5: Formulas
Test6: Phases, Gases
Test7: solusion equations
Final: All of the above

Table 3
Stepwise regression for test on gas laws,solusions and the periodic table

$R^2 = .818$, constant =100.06, $F_{2,5} = 11.255$ $p = .014$

variable	coefficient	S.D. error	t(8)	p
3 drill t	1.320	.481	2.75	.013
15 gas8 t	-1.950	.481	2.75	.025

Table 4
Stepwise regression for biology test1:

$R^2 = .867$, constant = 37.63 $F_{2,12} = 39.007$ $p = 0.000$

variable	coefficient	S.D. error	t(15)	p
a 2 ok	.644	.117	5.504	0.000
a 2 t	-.451	.117	3.855	0.002

Table 5
Stepwise regression for biology test2

$R^2 = .626$, constant = 82.04 $F_{2,12} = 10.004$ $p = 0.003$

variable	coefficient	S.D. error	t(15)	p
a 2 t	-1.121	.250	4.484	0.000
a 35 no	-.761	.250	3.044	0.008

Conclusions

Except with cases of very special lesson programing, it was found that on-line data can be a useful tool to follow and evaluate lesson development. Also the few exceptions can be corrected.

The correlations between student off-line test scores and on-line data measurements show that the time data and the no per question measurements are more measures of aptitude in the field more than knowledge of a certain skill. Percent of correct answer on first try is a measure of the knowledge of the specific skill. This conclusion comes from the last measurement being a predictor to tests that are on the exact same material, while the time and no per question predict tests which are not on the same materials, but from the same field.

Richard Murphy and Lola Appel (1977, pp44-45), of the Educational Testing Service, using the same data and data machinery, claimed that the on line data mesures that we provided them with could be used for small, well-designed studies of individual lessons or groups of lessons.

It seems that in each lesson the individual student can only be compared to the class means in the given measures.

It is recommended that the data be used as a warnning system rather than a final measure of the student ability.

There is no question that these measurements are a sensitive tool for the evaluation of lesson revisions.

References

Murphy Richard T. Murphy and Lola Rhea appel. Evaluatio of The PLATO IV Computer-based Education System in The Community College. Educational Testing Service, Princeton, New Jersey, 1977.

Tatsuoka K. & Siegel, M. Manual to Accompany "area" summary data and analysis package, Internal report. Computer-based Education Research Laboratory, University of Illinois, Urbana, Ill., 1975.

Tatsuoka, K. & Tatsuoka M. Time-score analysis in criterion-referenced tests. Progress report to Basic Skill group of the National Institute of Education for October 1, 1976-April 30, 1977. University of Illinois, Urbana, Ill., 1977.

Weaver, T. & Lederman B. A supplemental package for -qarea- (Chapter 5) in *On-line Data Collection* compiled by Dibello, L. V., Community College Math Group Interim Report, Computer-Based Education Research Laboratory, University of Illinois, Urbana, Ill., 1975.

Weaver A. Tamar and Francis Larry, Internal Report for MTC project Analysis of Student Data in Computer-based Education University of Illinois, Urbana, Ill., 1975.

THE IMPACT OF AN "OUT-OF-CLASS" CBI PROGRAM

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PURPOSE

The purpose of this study was to determine the impact of a change in format of student usage of computer-based instruction (CBI) from primarily scheduled class usage to primarily free-period usage. Such a policy change was carried out during the 1976-77 academic year at the City Colleges of Chicago, a community college system where PLATO (University of Illinois) has been used since 1972. This policy change resulted from an interpretation of funding guidelines that CBI was to be offered as a supportive service on a supplementary basis.

This study is focused on the CBI program at Kennedy-King College, one of the City Colleges of Chicago. The CBI program at Kennedy-King was initiated in November 1972 and has supported an intensive student usage program since the beginning of the 1974-75 academic year. Several thousand Kennedy-King students have studied hundreds of CBI lessons developed by faculty and staff of the City Colleges and by other PLATO authors in a variety of academic areas, chiefly biology, chemistry, English, and mathematics.

The results of this study will help CBI program administrators determine the feasibility of an out-of-class student usage program at their sites, and it will offer them guidelines for administering such a program.

PROBLEM

The PLATO Project staff of the City Colleges (including a coordinator and two lab assistants at Kennedy-King, as well as a director for the City Colleges and site personnel for three other campuses) faced the problem of how to facilitate the smooth transition of "in-class" student usage to "out-of-class" student usage so that the overall amount of usage, student achievement, and student attitudes would not be adversely affected.

Several constraints were posed by the policy change:

1) there was only a month's notice of the policy change; 2) available ECS (Extended Core Storage, or the amount of computer lesson space) was in such short supply that it might be difficult to accommodate more than eight or nine different lessons at any one time although there were 24 terminals; 3) some students would not have free time, while others would not use PLATO during their free time; and 4) faculty would no longer accompany their students to PLATO, which meant that content consultation would be severely curtailed.

The PLATO Project staff made three assumptions in their assessment of the situation: 1) students who were not encouraged to use CBI by their instructors would generally not use it; 2) faculty who were not involved in policy decisions would make less use of CBI and would be less likely to encourage their students and colleagues to use CBI than faculty who were involved; and 3) faculty who had used CBI previously and who had held positive attitudes towards CBI would continue to use it despite the policy change.

PROGRAM IMPLEMENTATION

Several methods were used to help solve the problem:

1) Former PLATO users who were faculty were informed of the change on a personal basis, as well as by letter, during student registration. It was only a few weeks before spring semester registration that a commitment to make the policy change was made. This was also a time when faculty were on vacation. Sending the faculty a memorandum noting such an important change might have been interpreted as a callous administrative directive. On the other hand, waiting until after registration to announce the change would have resulted in less student usage. Registration afforded an excellent time for personally contacting former faculty users about the change.

2. Faculty involvement in CBI was strongly encouraged in several ways:

a. Former faculty users were asked to suggest ways to implement the new policy. Many of their suggestions were used to recruit faculty users for the spring semester, e.g., offering verbal encouragement to students during classes to use CBI, granting extra credit for time spent using CBI lessons or for the number of lessons completed, and making specific CBI assignments.

b. Previous faculty users were requested to bring their classes for one or two introductory sessions during which their students would receive a short demonstration followed by lessons previously selected by their instructor. These introductory sessions were conducted primarily during the first three weeks of the spring semester. It was hoped that these sessions would permit more students to use CBI as soon as possible, to allow for more open usage throughout most of the semester, and to lessen the need for giving demonstrations to individual students.

c. Curriculum development groups representing biology, chemistry, English, and mathematics were continued, and released time (1/4 load) was given to a few instructors, including two Kennedy-King instructors, for participating in the curriculum meetings and for developing CBI lessons.

d. Several faculty were encouraged to participate in mini-experiments in which CBI format was compared to lecture format for various topics.

e. Adult education instructors who taught basic academic skills were allowed to continue having their students use PLATO as part of in-class laboratory work.

3. An hourly schedule was prepared each week. The schedule listed any scheduled classes or three priority subjects each hour from 9 a.m. to 5 p.m., daily. The total number of times a particular subject was listed each week was based on the amount of usage that subject had received in previous semesters. At Kennedy-King, biology, chemistry, and English were listed most often. The subject listing was arranged to help ensure that students wanting to study a particular subject would be given some priority should there not be enough available terminals or computer lesson space. If a student were initially unable to use a lesson in one of the three priority subjects, he or she could request assistance from a PLATO staff member. If necessary, a student studying a lesson in a subject not listed that hour would be asked to return later. The other hours of PLATO availability (8 a.m. to 9 a.m., daily; 5 p.m. to 9 p.m., Monday through Thursday; and 5 p.m. to 6:30 p.m., Friday) did not require the listing of priority subjects because there was ample computer lesson space then.

4. On-line curriculum modules for various courses and subjects included an index of lessons which had been approved by appropriate curriculum development groups. Such a lesson index was particularly helpful for those students who were not in any of the CBI courses which were set up by an instructor.

DATA COLLECTION

PLATO usage data collected both before and after the policy change was analyzed. To help determine the affective consequences of the policy, a comparison was made of student attitudes towards CBI as shown on surveys administered before and after the policy change. The student questionnaires developed for the fall and spring semesters were based on one used by the Educational Testing Service to assess student attitudes towards CBI (Murphy and Appel, 1977). Faculty attitudes towards the new policy were solicited by questionnaire and by interview.

The data was not analyzed by the use of significance tests because experimental conditions could not be applied throughout. Instead, the data was summarized and discussed using usage figures and percentages (e.g., x% of the students under the in-class usage policy compared to y% of those under the out-of-class usage policy agreed that they would encourage their friends to take a course that uses PLATO).

No attempt was made to compare student achievement before and after the policy change other than through the attitudinal questionnaires. Although data on student achievement was collected in the mini-experiments, this information really compared CBI format to lecture format.

USAGE RESULTS

Total student and faculty contact hours* of PLATO use for the fall semester 1976 and for the spring semester 1977 were 15,517 and 14,712, respectively, or just under a 5.2 percent drop in total usage. Student usage for the two semesters was 14,054 and 12,667, respectively, or nearly a 9.9 percent drop in student usage. These figures reflect increased author and instructor usage of PLATO from 1463 contact hours in the fall semester to

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*"Contact hours" as used here represents a tally of student users made once each hour on the half-hour.

2045 in the spring semester, representing a 39.9 percent increase in this type of usage. The number of faculty who had their students use CBI increased from 49 (87 courses) to 56 (101 courses), or an increase of 14.3 percent (16.1 percent increase in the number of courses).

The academic areas most often studied on PLATO during both semesters as indicated by on-line data showed biology and English ranked first and second, respectively. GED mathematics moved ahead of chemistry in terms of usage, which was followed by college mathematics and accounting. Other academic areas studied included data processing, engineering, music, physics, social science, and Spanish. Typing was added during the spring semester.

During the fall semester, an exact total of the number of different student users from on-line data cannot be determined because some of the usage was with special sign-ons called "multiples," which allow any number of students to use the same sign-on name. It is estimated that the total number of student users during the fall semester was 2,000. This increased to 2904 during the spring semester, including 309 students who signed on PLATO less than fifteen minutes. It should be pointed out that a number of students used PLATO in groups of two or three. An attempt was made to count everyone in the tallies, but, of course, computer-logged hours did not record their use.

In short, more students were served during the spring semester but for a shorter time, averaging just over three terminal hours each, and more faculty were served during the spring semester, as well.

Technical Constraints

The major technical constraints included terminal breakdowns, computer failures, and lack of computer lesson space (ECS). Terminal breakdowns, i.e., the average number of inoperable terminals per day, was about 1.2 out of 24 terminals for both semesters. It is interesting to note that this represented a substantial decrease in terminal failures from a daily average of five in the fall of 1974.

Computer system failures remained constant over the two semesters: PLATO "off" time including system and terminal failures was about five percent.

The most pressing constraint during both semesters, but particularly during the spring semester, was a lack of sufficient computer lesson space, which was somewhat inadequate to accommodate out-of-class usage. During mid-morning and afternoon hours, PLATO was able to serve no more than eight or nine different lessons at the same time. There was no way of determining just how many students were turned away or turned off because of this difficulty.

STUDENT ATTITUDES*

The fall survey (see p.13) posed twenty questions to which students could either "agree" or "disagree" and two open-ended questions requesting students to list what they liked and disliked most about PLATO. Students were also asked if they had used PLATO prior to the fall semester 1976. The twenty forced-choice questions were listed in random order. Each question could be placed into one of three categories: overall attitude, lesson characteristics, and mechanical aspects. The questions used in the spring survey were nearly the same except that inappropriate questions referring only to class use were eliminated or reworded. In the spring semester questionnaire (see p. 15), students were also asked to indicate whether they preferred to use PLATO with their class or on their own.

Procedures

Because the type of usage for the two semesters differed, the procedures used to administer the surveys also differed. Toward the end of the fall semester, copies of the questionnaire were given to the 42 instructors who had had their students use PLATO during at least three class sessions. Most of the students in these classes had used PLATO at least seven hours during the semester, a few more than thirty hours. In the spring semester, students who happened to be using PLATO during two selected days near the end of the semester were given the survey.

Results

A total of 758 copies of the fall questionnaire were completed and returned. Most were from biology classes (41 percent) and English classes (30 percent), reflecting the high usage by classes in these two academic areas. The rate of return was more than 85 percent of the copies of the questionnaire that were distributed by the instructors. Only 139 copies were received during the spring survey because of the different method used to administer the questionnaire. Biology (49 percent) and English (14 percent) users were also highly represented in the spring survey, reflecting the high usage by students in these areas. Most of the spring survey respondents were using PLATO during their free time when surveyed; some of them were part of a class using PLATO.

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*Information presented here on the fall 1976 survey study was adapted from the author's article (Magidson, in press).

On the fall survey nearly 40 percent of the respondents indicated that they had used PLATO in a previous semester compared to 31.4 percent of those responding on the spring survey. Unfortunately, 18 percent of the fall semester subjects failed to answer this question compared to only one percent of the spring semester subjects.

The number of responses to each question and percent of "agree" responses are given in Table I (p.14) and in Table II (p.16). The results on both questionnaires were highly favorable in terms of the students' overall attitude towards PLATO, attitudes towards lesson characteristics, and attitudes towards the mechanical aspects. The percentages given are based on the total number of students responding to a particular question.

Concerning the students' overall attitude towards PLATO, 93.1 percent of the fall survey respondents compared to 94.9 percent of those responding to the same question on the spring survey agreed that they "would encourage their friends to take a course that uses PLATO." Only 6.8 percent of the fall survey respondents and only 6.2 percent of the spring survey respondents agreed that "using PLATO is boring." Only 10.2 percent of the fall survey respondents and only 15.2 percent of the spring survey respondents agreed that "PLATO makes me feel as though I am not a person." It is interesting to note that 91.2 percent of the fall semester respondents compared to 86.7 percent of the spring semester respondents agreed that "PLATO allows me to assume greater responsibility for my own work."

Concerning PLATO lesson characteristics, 93.2 percent of the fall survey respondents and 91.1 percent of the spring survey respondents agreed that they "like PLATO because it lets you take part at each step in the lesson." Over 91 percent of the fall and spring survey respondents agreed that "PLATO made good use of examples and illustrations"; 88.1 percent of the fall survey respondents and 89.7 percent of the spring survey respondents agreed that "PLATO made helpful comments on my work." About 7.5 percent of the fall survey respondents and 10.3 percent of the spring survey respondents agreed that most PLATO lessons were too difficult.

Concerning the mechanical aspects of PLATO, only 11.0 percent of the fall survey respondents and 14.4 percent of the spring survey respondents agreed that the "mechanics of using the PLATO terminal distracted me from learning." Over 90 percent of the respondents on both surveys agreed that they "felt comfortable working with PLATO," and only 11.9 percent of the fall survey respondents and 16.5 percent of the spring survey respondents agreed that "PLATO makes it difficult for me to learn because it always seems to be breaking down."

In only two instances were the differences in opinions between the two survey groups above seven percentage points and in these areas each difference was less than ten percentage points. Over 16 percent of the fall survey respondents agreed that "generally, PLATO did not give clear explanations of the material." The fact that students in the spring semester were more on their own in selecting lessons may help account for this difference. Just over 66 percent of the fall survey respondents compared to 75.2 percent of the spring survey respondents agreed that they "learn better in classes using PLATO than in classes that don't."

A comparison was made of the responses of those students who had indicated on the spring survey having used PLATO under both policies to those who indicated they were new users. The more experienced users noticed operational problems more often: 30.0 percent compared to 11.0 percent of the new users felt "PLATO makes it difficult for me to learn because it always seems to be breaking down," and 18.6 percent of them compared to 12.8 percent of the new users indicated that "the mechanics of using the PLATO terminal distracted me from learning." Perhaps these difficulties contributed to more of the experienced users feeling that PLATO was dehumanizing (25.6 percent to 9.6 percent). More of the students who had used PLATO in previous semesters noted that lessons were not giving "clear explanations of the material" (30.2 percent to 21.1

percent); yet they were more inclined to "encourage... friends to take a course that uses PLATO" (100 percent to 92.5 percent).

Over 72 percent of the spring survey respondents to the question on which way they preferred to use PLATO indicated "on my own" rather than "with my class." Nearly 61 percent of those who had indicated having used PLATO in previous semesters preferred using PLATO on their own time.

The open-ended answers on both questionnaires conformed to the overall positive impression indicated by the responses to the forced-choice questions. The most frequent answer to what students liked most on the fall form was "everything" (frequency of 42), which was the second most frequent answer (15) on the spring form. Other favorable responses with the highest frequency on both forms were categorized as "helpful," "clear and concise," and "step-by-step learning."

Not surprisingly, the most common response to what the students disliked most about PLATO was "none" or "nothing" (frequency of 88 on the fall form and 23 on the spring form). Although most of the unfavorable comments on the fall survey concerned the mechanical characteristics and failings of the computer and terminal, various kinds of difficulties with the lessons themselves were given most often on the spring survey.

Here are a few student comments from both semesters which reflect the students' overall opinion of PLATO:

1. "I found that if I didn't quite understand the teacher and went to PLATO, between the two of them I got some sort of understanding" (fall survey).

2. "I liked the humor of the machine" (fall survey).

3. "The breakdowns are a nuisance sometimes... There are very few criticisms that I can offer regarding the use of PLATO. I wish I had used it in previous years" (spring survey).

FACULTY ATTITUDES

Faculty who had their students use PLATO during the spring semester 1977 were surveyed to determine their attitudes towards PLATO in light of the new policy.

Nearly 93 percent (52 of 56) completed the questionnaire (see p.17). Forty-one or 78.8 percent of the respondents had accompanied their students to use PLATO less than three class periods. On the other hand, 57.7 percent had used PLATO with their students more than seven sessions during the fall semester.

Over 69 percent of the survey subjects favored the in-class usage policy, but only 7.7 percent indicated either that they were "not really sure whether or not I would use PLATO" again (3) or that they would "probably not" use PLATO again (1). No one indicated that they would "never" again use PLATO. Over 63 percent indicated that they would "absolutely" use PLATO again.

The most serious problems for their students were identified as "lack of computer space" (ranked first), followed by not "enough terminals" (ranked second). The faculty users seemed most satisfied with the appropriateness and the quality of the lessons.

The statement checked most often concerning possible attributes of PLATO was "gives students experience not otherwise feasible" (80.8 percent), followed by "saves time of instruction (53.8 percent), and by "allows better teaching of regular material"(50 percent).

In short, the faculty PLATO users were highly favorable towards CBI and towards continuing to have their students use CBI on an out-of-class basis despite their preference for in-class usage.

CONCLUSIONS AND RECOMMENDATIONS

Despite the lack of computer lesson space during prime-time usage and the short notice, the policy change from primarily class usage of CBI to primarily open usage was carried out successfully at Kennedy-King College during the spring semester 1977. There was only a 5.2 percent drop in total usage from 15,517 contact hours in the fall semester to 14,712 in the spring semester. Although student usage declined by 9.9 percent, author and instructor usage increased by 39.9 percent. The number of faculty who had had their students use CBI increased by 14.3 percent from 49 to 56.

The number of different students who were served increased from an estimated 2,000 in the fall semester 1976 to 2904 in the spring semester. Although there were substantially more students who used PLATO during the spring semester than in the fall semester, the mean terminal hours of usage in the spring was much less.

Both student and faculty attitudes towards PLATO continued to be highly positive, though faculty preferred the in-class usage policy (69 percent of the faculty who were surveyed).

Student assessment of PLATO yielded these results: 1) they enjoyed using PLATO; 2) they did not believe it to be dehumanizing; 3) they found its use helpful as a learning aid; 4) they experienced only minor difficulties operating the terminal; and 5) they believed that computer and terminal breakdowns posed some difficulties. Students who had used PLATO under both policies were probably more realistic in their assessment. They were more aware of lesson difficulties and terminal and computer breakdowns.

Faculty users of PLATO identified "lack of computer space" and not "enough terminals" as the most serious problems. They were most satisfied with lesson quality and appropriateness. They checked "gives students experience not otherwise feasible" and "saves time of instruction" most often as attributes of PLATO.

The policy change was also successful in light of these limitations: 1) many Kennedy-King College students have work or child-care commitments which severely limit their engaging in non-class activities; 2) the program had operated on an in-class basis for several years prior to the change, which meant that the program staff were much more experienced in administering in-class usage; and 3) the in-class usage policy makes CBI usage compulsory and thus assures comparatively high usage, while an out-of-class usage policy offers no such assurance.

The out-of-class usage policy has given students a greater opportunity to use CBI on a more independent and individualized basis. It has compelled students to be more responsible for their learning.

Recommendations

Administrators should take note of the following recommendations for achieving a successful CBI program:

1. Faculty involvement is important for encouraging high CBI usage and for ensuring that students will receive support and guidance and appropriate instruction. Instructors will also involve a large number of students through their courses, which will facilitate administration of the program, and they will be the best advocates for involving other instructors.

2. Curriculum development groups for specific academic areas and composed of faculty and CBI staff should be established to identify appropriate CBI lessons, to review and revise lessons, to organize student testing of lessons, and to suggest on-line curriculum modules including lesson indexes.

3. Some in-class usage, particularly introductory CBI sessions and some in-class laboratory sessions, should be retained.

4. A system of scheduling priorities should be set up to offer students some assurance that they will be accommodated. Scheduled classes, although restricted in a primarily open-usage program, should have highest priority, followed by usage in pre-selected academic areas, followed by other usage. Instructors and authors might best fall into the second category, or there might be one or two terminals set aside for their use. It is best not to schedule individual students or particular lessons during each hour because such scheduling may discourage high usage and may be difficult to administer. If possible, it is best to establish rules which permit students to use CBI at any available time with the understanding that they may be asked to leave if a student with a higher priority needs the terminal or more computer lesson space. Either an on-line site managing system or site personnel should administer the scheduling priorities. Copies of the schedule should be posted weekly and distributed to faculty CBI users.

REFERENCES

Magidson, Errol M., "Student Assessment of PLATO: What Students Like and Dislike about CAI," Educational Technology, in press.

Murphy, Richard T., and Appel, Lola Rhea, Evaluation of the PLATO IV Computer-based Education System in The Community College, Final Report, Contract No. NSF-C731. (Princeton, NJ: Educational Testing Service, June 1977), A-143-44.

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Fall 1976

STUDENT PLATO SURVEY

COURSE AND SECTION ______________________ INSTRUCTOR ____________________________

Have you used PLATO before this semester? __YES __NO

Please answer the following questions to give your opinions of PLATO. Your responses will help us evaluate and improve PLATO. Thank you.

1. I like PLATO because it lets you take part at each step in the lesson. . . . . __AGREE __DISAGREE
2. PLATO is nothing but a baby-sitter for the teacher. . . . . . . __AGREE __DISAGREE
3. I enjoyed using PLATO. . . . . __AGREE __DISAGREE
4. Generally, PLATO did not give clear explanations of the material. __AGREE __DISAGREE
5. I felt comfortable working with PLATO. . . . . __AGREE __DISAGREE
6. I would encourage my friends to take a course that uses PLATO. . __AGREE __DISAGREE
7. PLATO makes me feel as though I am not a person. . . . . __AGREE __DISAG
8. PLATO made good use of examples and illustrations. . . . . . . __AGREE __DISAGREE
9. Too much time was spent in this course using PLATO. . . . . . __AGREE __DISAGREE
10. PLATO makes it difficult for me to learn because it always seems to be breaking down. . . . . __AGREE __DISAGREE
11. I like PLATO because you can make mistakes without being embarrassed. . . . . __AGREE __DISAGREE
12. I learn better in classes using PLATO than in classes that don't. __AGREE __DISAGREE
13. Most PLATO lessons are too hard for me. . . . . __AGREE __DISAGREE
14. PLATO seemed to know when I didn't understand the material. . __AGREE __DISAGREE
15. PLATO made helpful comments on my work. . . . . __AGREE __DISAGREE
16. Even though I could have left PLATO at the end of the class period, I often continued working for at least a few minutes. . __AGREE __DISAGREE
17. PLATO allows me to assume greater responsibility for my own learning. . . . . __AGREE __DISAGREE
18. The mechanics of using the PLATO terminal distracted me from learning. . . . . __AGREE __DISAGREE
19. Using PLATO is boring. . . . . __AGREE __DISAGREE
20. Computers ought to become more important in the everyday life of our society. . . . . __AGREE __DISAGREE
21. Please list the things you liked most about PLATO:
22. Please list the things you disliked most about PLATO:

TABLE I

Results of the Fall 1976 Student Survey on PLATO

Question	No. "agrees"	No. "disagrees"	Percent "agrees"
(Used PLATO before)	248	374	39.9
1	700	51	93.2
2	67	670	9.1
3	715	35	95.3
4	121	626	16.2
5	679	66	91.1
6	683	51	93.1
7	74	649	10.2
8	671	60	91.8
9	63	682	8.5
10	88	651	11.9
11	641	106	85.8
12	464	238	66.1
13	56	688	7.5
14	563	178	76.0
15	651	92	88.1
16	588	155	79.1
17	674	65	91.2
18	82	663	11.0
19	50	685	6.8
20	481	232	67.5

Spring 1977 4/77
STUDENT PLATO SURVEY

PLATO Course Code ______________________________

Please answer the following questions to give your opinions of PLATO. Your responses will help us evaluate and improve PLATO. Thank you.

1. Is this the first semester you have used PLATO? . . . . . . __YES __NO
2. I like PLATO because it lets you take part at each step in the lesson . . . . __AGREE __DISAGREE
3. Generally, PLATO did not give clear explanations of the material . . . . __AGREE __DISAGREE
4. I felt comfortable working with PLATO . . . . __AGREE __DISAGREE
5. I would encourage my friends to take a course that uses PLATO. __AGREE __DISAGREE
6. PLATO makes me feel as though I am not a person . . . . __AGREE __DISAGREE
7. PLATO made good use of examples and illustrations . . . . . __AGREE __DISAGREE
8. PLATO makes it difficult for me to learn because it always seems to be breaking down . . . . __AGREE __DISAGREE
9. I like PLATO because you can make mistakes without being embarrassed . . . . __AGREE __DISAGREE
10. I learn better in classes using PLATO than in classes that don't . . . . __AGREE __DISAGREE
11. Most PLATO lessons are too hard for me . . . . __AGREE __DISAGREE
12. PLATO seemed to know when I didn't understand the material. __AGREE __DISAGREE
13. PLATO made helpful comments on my work . . . . __AGREE __DISAGREE
14. Sometimes I used PLATO for a longer time than I had planned. __AGREE __DISAGREE
15. PLATO allows me to assume greater responsibility for my own learning . . . . __AGREE __DISAGREE
16. The mechanics of using the PLATO terminal distracted me from learning . . . . __AGREE __DISAGREE
17. Using PLATO is boring . . . . __AGREE __DISAGREE
18. Which way do you prefer to use PLATO: ___With my class ___On my own
19. Please list the things you liked most about PLATO:
20. Please list the things you disliked most about PLATO:

TABLE II

Results of the Spring 1977 Student Survey on PLATO

Question	No. "agrees"	No. "disagrees"	Percent "agrees"
1	94	43	68.6
2	123	12	91.1
3	32	100	24.2
4	124	13	90.5
5	130	7	94.9
6	21	117	15.2
7	125	12	91.2
8	22	111	16.5
9	115	21	84.6
10	100	33	75.2
11	14	122	10.3
12	107	26	80.5
13	122	14	89.7
14	115	20	85.2
15	117	18	86.7
16	20	119	14.4
17	8	130	5.8
18	34	89	27.6

FACULTY PLATO SURVEY: SPRING 1977

Dear Colleague:

We would be very grateful if you would take a few minutes to indicate your opinions of PLATO on this survey. Please return the completed survey form to the site coordinator at your college.

1. Name________________________________

2. Department_____________________ College____________

3. Class(es) using PLATO this semester (give PLATO course names):

number of classes.........	1	2	3	4	5
for each instructor......	25	16	5	5	1

4. How many times have you accompanied each of your classes to PLATO:

number of times.......	0	1-2	3-4	5-6	7+
for this semester.....	3	31	7	2	8
for last semester.....		7	3	1	30

(did not use PLATO last semester)__11__

5. Which way do you prefer having students use PLATO?

as part of class time__36__
on an out-of-class basis__16__

6. What are your opinions or suggestions regarding the out-of-class usage policy?

7. In the event you are teaching courses next semester for which there are applicable PLATO lessons, will you have your students use PLATO?

__0__ Never
__1__ Probably Not
__3__ Not really sure
__15__ Probably would
__33__ Absolutely!

8. How did you encourage your students to use PLATO on their own time (e.g., made required assignments, gave special credit)?

giving assignments (24)
giving credit (18)

9. Would you like to have PLATO used more to administer and grade quizzes?

10 Yes   42 No

10. Which of the following were problems for your students who used PLATO? Please use this rating scale:

1 = never a problem, 2 = a minor problem

3 = a major problem

1	2	3 (frequency given below)
32	12	1....Lessons not designed for our students
32	11	2....Low quality of lessons
16	23	7....Lack of lessons on desired topics
17	22	7....System failures in the middle of lessons
19	19	6....Keeping terminals repaired
7	24	14....Having enough terminals for all students
8	19	18....ECS (can't use all lessons at all times; lack of computer space)
15	28	3....Student difficulties in use of equipment

11. Check the statements which you believe are true of PLATO:

42 Gives students experience not otherwise feasible

26 Allows better teaching of regular material

25 Permits more to be covered

20 Saves time of students

28 Saves time of instructors

21 Gives instructor better idea of student needs

(Survey subjects (instructors) by academic area:)

English	13	Mathematics	4
Biology	11	Engineering	2
GED Mathematics	8	Accounting	1
Chemistry	5	Other	8

Types of Student Feedback in Physical Diagnosis Lessons

by

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ABSTRACT

Feedback to the student is a crucial part of any form of instruction. Different feedback formats were utilized on a series of computer assisted lessons on physical diagnosis for the second year medical students. All of these lessons were developed on the PLATO system.

Each lesson in the series is broken down into four to five major sections. In each section the student is presented with a list of actions that can be taken. On each item three forms of feedback, two of which are generated by the computer, are received.

The first type of feedback is ranking the items on the list in the order in which the student would do them. On completion of the section, the student's ranking is compared against that of the author's and his peers'. Using the Spearman Rank-Correlation Coefficient, a numerical value is obtained for each comparison.

The second feedback component in the series is that of the "good/bad" judgement. The student is asked on each entry in the list whether or not he feels a particular action is appropriate. His response is then immediately compared against the author's, and he is informed of the result. Running totals are kept, and are always presented to the student. The student can also see how the other students fared on that particular question.

The final and more personalized form of feedback is the short essay. In this case the student is asked for his opinion, in his own words, on the action. These essays are then stored, and later printed out for the class instructor to read, review, and comment on and hand back in class. In this way, the class instructor is kept aware of the student's progress.

INTRODUCTION

During the clinical phase of medical education a great deal of emphasis is placed on "decision making." The value of this skill can be clearly seen in the management of the patient. No diagnosis can be made and no treatment administered without traversing the proper decision path. The decisions that the physician has to make arise in many different areas from what questions to ask in a history taking session (maintaining a good rapport with the patient is essential), to which procedures to be performed in a physical examination. This also becomes obvious when setting up the patient's treatment plan.

Educators advocate and employ a variety of teaching/learning techniques teaching the art of decision making and patient management. These techniques include role playing, simulated patient encounters with actors, videotaped analysis, audiotaped interviews, patient management problems on paper and computer simulations. With the exception of computer simulations, the rest of the techniques have been used in medical schools for a number of years.

This paper attempts to highlight the use of computer technology, especially PLATO, in the development of clinical simulations on history taking and patient management. Specifically, unique features of the instructional design i.e. interactive process, quantitative and qualitative feedback and integration of simulations within a course will be elaborated on.

Physical diagnosis is taught during the sophomore year at the University of Illinois. During this course, clinical teaching encompasses such activities as pre-clinical experiences on simulated models, student practice on each other and bedside teaching. In addition to these, at the Rockford School of Medicine of the University of Illinois students are given management problems involving physical diagnosis. Prior to developing of these problems on PLATO, physical diagnosis students were given a nine workbook series to complete and turn in at prearranged times during the quarter. The workbooks were broken up in sections with a number of items in each section. Students were asked to evaluate each item in essay form explaining the reasoning behind their evaluation.

Generally, the students described the workbook experience as inefficient and very restrictive in obtaining feedback. Thus, the course instructor wanted to explore other instructional options in which students can assume active roles as the problem solvers and are provided with instant feedback on their ability to master medical content. Such an alternate method is feasible on PLATO. Therefore, the nine clinical problem workbooks were adopted to a simulation format in the form of PLATO lessons (programs).

DESCRIPTION OF LESSON

The nine lessons that compose the series are similar in structure. A lesson is broken into logical categories with a list of choices presented to the student. A typical lesson contains four sections: history, physical examination, assessment and treatment. The list in a typical section will have four to twelve questions, actions or other choices from which the student can pick. This type of format leaves the pace and direction of the lesson in the hands of the student allowing him to use the lesson to his satisfaction. In this way, if the student wants to review some particular problem solving technique, he can go back to the section in question and look at it before going further.

Following a student's progress through a lesson will give a better idea of the structure. Upon entry, the student first sees some introductory comments and instructions. He is then given a short statement of the patient's problem along with a main index to choices in the workup of the patient. (Figure 1) In some cases, the index entries are only listed if certain criteria have been met, such as completion of prerequisite sections.

Once the student has chosen which phase of the workup he wishes to attempt, he is presented with the list of actions. The entries in the list are randomly ordered for every student. The student's task in the lesson thus is as follows:

1. The student is required to "rank" the questions/actions in the order in which he would ask/do them as an exercise in comparative clinical judgment. (Figure 2)

2. After making his choice, the student is then asked his opinion on the appropriateness of the question/action. This is done in the form of a binomial choice, such as in answering yes or no to the question "Do you think that this item is a good or a bad one?"

3. Completing the simple one word response, the student is then provided with a place where he can elaborate and expand on his judgment.

4. After finishing the essay, the student is then shown the patient reaction to his action. In the case of a history-taking question, it would be the patient's response. In a physical exam or lab test, it would be data obtained from the patient or test. In all other cases it would be the instructor's one word judgment of the appropriateness of a management decision probability of a diagnosis. Also presented is the instructor's comment about the significance of the item.

5. After reading the instructor's comment about the item, the student returns to the list of entries again.

This five step process is repeated until all the items in the section are "ranked", or if the student so desires he may interrupt the process and return to the main index, where he can choose to start another section. It should be noted that sections are not considered completed until all the entries are "ranked", though there is no penalty incurred if the student decides to go to a different section. Finally the lesson is considered complete only when all the sections are finished.

METHOD AND RESULTS

In clinical medicine, and especially in physical diagnosis, strong emphasis is placed on judgment: by asking questions and observing physical characteristics the doctor is expected to make the proper patient care decisions. In these simulations, the students are asked to make the very same type of decisions and judgments. "Decision-making" and "judgment" are extremely hard to teach in a large classroom environment because each student is at a different level. Individual teaching is the optimal solution, but obviously, it is also an infeasible one. This is where the lessons come in. They offer the individual tutoring that each student needs but do not impinge on other students' progress allowing each individual to work at his own speed.

Feedback is an integral part of any teaching method, providing the students with information. This information can come in many forms, from the simple "right" and "wrong" statements to an elaborate evaluation algorythm. The lesson's feedback system is made up of three different components, each returning a unique piece of information. Thus the student is provided with a comprehensive report on his learning process.

The first element of feedback is the most basic and the one the most often seen by the student: the "right/wrong" return on the student's binomial act of judgment. It is determined by doing a simple comparison of the student's response against that of the instructor. The student receives this feedback in two ways: first, a running total of the number of items answered correctly by the student and the number answered incorrectly. Thus the student is constantly aware of this ratio of correct to incorrect judgments and how it changes. The second way in which feedback on the bionomial judgment is given is the percentage of students answering the question correctly. The student is shown how many students attempted the question and what percent of these agreed with the instructor's answer.

This data is presented to the students along with the instructor's assessment on the worth of the proposed action.

The next component of the feedback system is the most elaborate, as it provides an evaluation of the item rankings done by the individual, the instructor, and class as a whole. On completion of each section, the student is shown three correlation coefficients: student-instructor rankings, student-class rankings, and class-instructor rankings. The student-class computation is made from the cumulative group rankings based on all previous students using the lesson. The same group is used for computing the class-instructor coefficient. The Spearman Rank-Correlation Coefficient (1) was used.

From the value of the correlation which is explained to the student when he sees it at the conclusion of every section, the student obtains information about the validity of his comparative judgment based on the judgment of the instructor and the judgment of the group. Since ranking is quite a subjective activity, no significance for this measure can be claimed. It is interesting to note, however, that in general high correlations were obtained between the instructor and the class from the beginning of the series (Table 1). However, no definite pattern was observed on some of the problems completed by the students. More complete data will be available by the time of the presentation of the paper.

The third type of feedback is a carry-over from the workbook format: the essays. Each student is required to write an essay explaining his "good/bad" judgment on each item. These essays are written and stored on-line (in a special PLATO file called a notes-file), printed out weekly and then sent to the instructor for his review. After writing his comments on the printouts, the instructor hands them back in class. Thus the student is provided with a hard-copy of his performance. Alternately, the instructor could respond on-line to each essay and then receive a hard copy. In this instance, due to the instructor's heavy schedule and distance from a terminal, this option was not utilized.

Essay type student response forces students to articulate their position. This reduces "cueing effect" which is quite common with simulation designs with pre-formulated answer responses.(2)

CONCLUSION

As of this writing, the first group of students to use the lesson series has not been completed; therefore, a very limited student feedback was available for reporting. Generally, the students liked the instructional design features such as instant feedback, ability to express individual responses in the essay and the overall ranking with the instructor.

In addition, students have furnished very insightful comments to improve the design of the existing lessons. For example, in the area of instructor feedback, students were having difficulty in understanding the overall logic behind the instructor's position on ranking certain items.

The students claimed that if they followed the logic of the instructor's opinion they would receive low coefficients. Also, if they did well on the "good/bad" judgment, their coefficients would still be low. One student expressed it this way: "How do you rank one bad procedure over another bad procedure?" This problem will be addressed carefully after the class has finished most of these lessons.

It should be pointed out that even though group and instructor rankings, correlations, numbers of right and wrong answers, percentage of students answering each question correctly, and instructor's assessment of each question were all constantly available during the course of the entire program, students were dissatisfied with the time lag between their completion of the essays and the return of the essays in class.

There was also a problem of logistics in that the fifty students are expected to share two terminals. More terminals are being added to alleviate the problem of scheduling.

REFERENCES

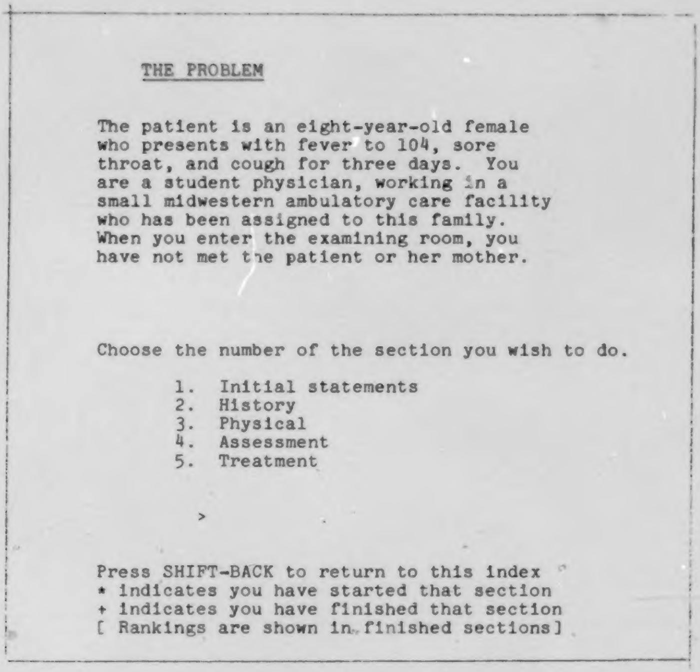
(1) Glass, Gene V. and Julian C. Stanley, Statistical Methods in Education and Psychology, Prentice-Hall, Inc. 1970.

(2) McGuire, Christine, Solomon, Lawrence and Bashook, Phillip, Construction and Use of Written Simulation, The Psychological Corporation, 1976.

SECTION TOPICS

LESSONS IN ORDER OF COMPLETION	INITIAL OPTIONS	HISTORY	PHYSICAL EXAM	ASSESSMENT	TREATMENT
SORE THROAT	-1.000	0.571	0.964	0.800	0.721
EAR INFECTION	1.000	0.806	0.257	0.500	0.767
INDIGESTION	-----	0.418	0.458	1.000	0.714
COUGH	-----	0.538	0.758	0.800	0.150
STOMACH TROUBLE	-----	0.531	0.800	0.900	0.698

Table I
Class - Instructor Correlation Coefficients Indicating Amount of Agreement in Ranking of Choices in Physical Diagnosis



THE PROBLEM

The patient is an eight-year-old female who presents with fever to 104, sore throat, and cough for three days. You are a student physician, working in a small midwestern ambulatory care facility who has been assigned to this family. When you enter the examining room, you have not met the patient or her mother.

Choose the number of the section you wish to do.

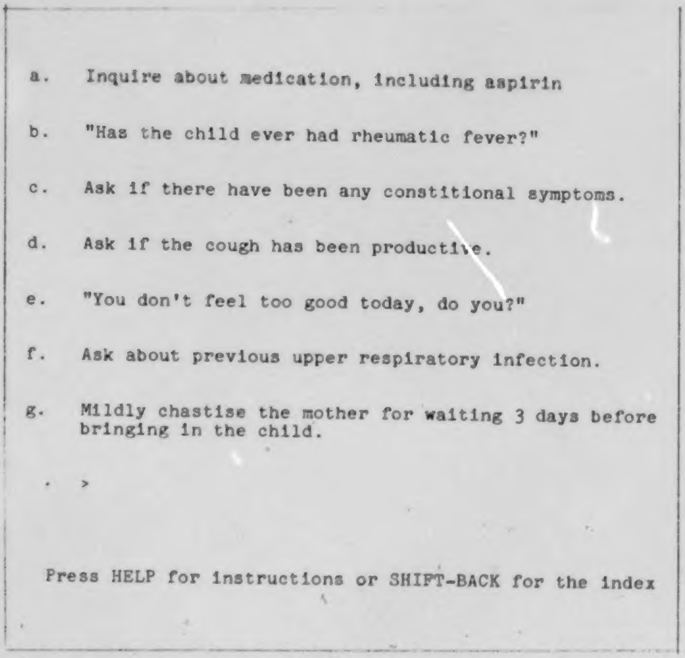
1. Initial statements
2. History
3. Physical
4. Assessment
5. Treatment

>

Press SHIFT-BACK to return to this index
* indicates you have started that section
+ indicates you have finished that section
[Rankings are shown in finished sections]

Figure 1.

Typical "problem statement" and "section index" for a Physical Diagnosis lesson



```
a.   Inquire about medication, including aspirin

b.   "Has the child ever had rheumatic fever?"

c.   Ask if there have been any constitional symptoms.

d.   Ask if the cough has been productive.

e.   "You don't feel too good today, do you?"

f.   Ask about previous upper respiratory infection.

g.   Mildly chastise the mother for waiting 3 days before
     bringing in the child.

  .  >


 Press HELP for instructions or SHIFT-BACK for the index
```

Figure 2

Typical Randomized Item List in One Section of a Physical Diagnosis Lesson. Students Must Rank the Items, Choosing the Best Ones First

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MEDIA SELECTION: ALTERNATIVE DELIVERY SYSTEMS

A Paper Presented at the 1978
Conference of the Association for the
Development of Computer-Based
Instructional Systems at Dallas, Texas

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Introduction

In the near future, computers may be capable of replacing almost every other medium of instruction. It may appear anachronistic to be concerned with the selection of various instructional media since the computer could do most everything. However, it will still be necessary to select which form of the computer's many capabilities should be utilized in presenting a set of instructional materials. While yet unproven, it would appear that many of the traditional media selection models could be directly transferrable to computer capability selection.

This paper will focus on the traditional instructional design element of media selection, explain the development of media selection by presenting several models, and suggest some areas for study which are of particular importance for computer-assisted instruction.

Definition

Media selection has come to have various definitions depending on the frame of reference of the selector.

To classroom teachers, media selection often means choosing a commercially-produced package to integrate into a classroom session (Moses & Watt, 1976).

To administrators and librarians, media selection is an evaluative process preceding the purchase of print and non-print materials for resource centers (Alexander & Hempstead, 1976; n.a., School Media Quarterly, 1977).

To instructional designers, media selection is choosing a delivery system for the presentation of learning objectives. The medium selected should present a system as similar as possible to the final learner task in order to promote high positive transfer (Allen, 1967).

It is from the instructional design standpoint that this paper will address media selection.

Background

A model of instructional design which is currently in wide use is the Florida State model (Dick & Gallagher, 1972).

The Dick model has 10 distinct steps. The relationship as well as sequence of the steps for preparing instructional materials is shown in Figure 1.

Model for the Systems Approach to the Development of Instructional Materials

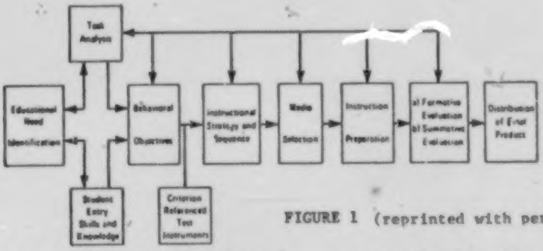
Task Analysis
Educational Need Identification
Behavioral Objectives
Instructional Strategy and Sequence
Media Selection
Instruction Preparation
a) Formative Evaluation
b) Summative Evaluation
Distribution of Final Product
Student Entry Skills and Knowledge
Criterion Referenced Test Instruments

FIGURE 1 (reprinted with permission)

It is often the case in reality that the medium of instruction is selected out of sequence before some of the preceding steps have been performed (Diamond, 1977). It is not unusual to hear educators, even educational technologists, say, "We should have a tape/slide, or a videotape, or a computer program to teach that."

While it may be true that the chosen medium will be the most effective for the intended purpose, it is premature to select a delivery mode at that early point in the design process. The Dick model and other validated instructional design models (Romiszowski, 1974; Kemp, 1977; Gagné & Briggs, 1974) postpone the selection of media until late in the design of instruction.

Method

The selection of media is based on the behavioral objectives defined for the instruction. Precise and specific statement of behavioral objectives early in design make subsequent design steps easier to perform.

From the behavioral objectives is derived the information about what action the student is expected to perform in order to demonstrate proficiency in a learning task.

Viewed in stimulus-response terms, the behavioral objective states the learner response (Ausburn, 1976; Gilbert, 1962). It is the task of the designer to determine what stimulus will best elicit the desired response. Not only is it incumbent upon the designer to select the "best" stimulus, s/he must also consider the learners' modality preferences, size of group receiving instruction, instructional treatment and strategy, and cost of producing the materials among other things.

In order to deal with these variables and others, the old selection principle of "choose the appropriate medium" has ceased to be functional for designers. In striving to be scientific, media selection has become more controlled and predictable.

Models of Media Selection

In providing an operational framework for designers, several different media selection models have been developed. Prior to using these models, the designer should realize that the stimulus-response interaction is not the simple process which it might appear to be.

The learner who is to provide the response brings with her/him a plethora of characteristics. Some of these characteristics may enhance response production; some may interfere; some may inhibit the process entirely. The stimulus as well may have many characteristics to be considered. Together the stimulus-response interaction form part of the predicted performance outcome.

Ausburn, 1977, p. 5
Diagram withheld
pending publisher permission

FIGURE 2

The medium of instruction is a part of the connecting link. The medium is the delivery system (stimulus) by which the content (also a stimulus) is presented to the learner. If the content and delivery system components are properly selected, the result should be the desirable and predictable response of the student (Ausburn & Ausburn, 1976).

Gilbert (1962) advises the selection of mediators which are minimizers of energy for communication and which also do not compete for meaning with the instruction. He states that the competition consideration is critical in the shaping of new responses which may be weak or non-existent in the learner's response repertoire.

With this background information, the models proposed by Allen; Tosti & Ball; Boucher, Gottlieb, & Morganlander; Kemp; and Romiszowski, will be discussed.

The Allen model (1967) is an example of early work in the field of media selection. This selection matrix plots the type of learning vs. the media device type. To use this model, the designer simply looks across the row for the level task to be performed. After locating the potential media possibilities, the designer considers cost, production considerations, and availability in making a final decision (Figure 3).

Allen, p. 28
Diagram withheld
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FIGURE 3

Tosti & Ball (1969) added presentation form in their behavioral approach to media selection. The presentation form is comprised of six dimensions:

Tosti & Ball, p. 8
Diagram withheld
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This model necessitates the separation of presentation form from the media which deliver the form. This separation had not been made previous to the development of this model.

Five steps are necessary in using this model. First, the presentation factors are determined; next, the response is classified; finally, the management is designated (Figure 4).

Tosti & Ball, p. 14
Diagram withheld
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FIGURE 4

The designer then refers to two matrices which classify the media by encoding vs. duration and encoding vs. response demand (Figure 5).

Tosti & Ball, p. 22
Diagram withheld
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FIGURE 5a

Tosti & Ball, p. 22
Diagram withheld
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FIGURE 5b

These two matrices may yield no media choices or more than one choice. A voting procedure or closest approximation may have to be used for the situation. Ranking or weighting of the media choice capability to deliver the desired dimension may be helpful.

The final selection among the operational systems may have to be based on the external considerations of cost, availability, and market or user preference.

Ideally, Tosti & Ball would like a six-dimensional matrix which will be easier to use and more precise than this method.

The approach developed by Boucher, Gottlieb, and Morganlander (1973) is somewhat different (Figure 6). After stating the objectives of the instruction, each objective is analyzed with regard to its sense modality presentation modes. The response modality is also designated. Then feedback and learner interaction type are determined from the instructional strategy.

A media requirements worksheet (Figure 7) assists the designer in designating these parameters.

Also included in the Boucher et al model is a suitability rating scale indicating how well a device type will perform an instructional intent.

It is noteworthy that this model includes a description of computer-assisted instruction as one of the media choices, albeit brief. The authors testify to the diversity of CAI by stating that while being able to designate a complex scheme, called a data group, for other media types, "no data group can be produced for CAI per se." It is unusual, however, to find the computer included in a media selection model at all.

MEDIA CAPABILITES MATRIX	PRESENTATION														STUDENT RESPONSE						INSTRUCTIONAL STRATEGY						
	VISUAL								AUDITORY		TACTILE			KINESTHETIC CUES	VERBAL/ SYMBOLIC			PERFORMANCE			FEEDBACK			INTERACTION			
	PLANE (2D)	SOLID (3D)	LOCALITY (3D)	MOTION, FULL	MOTION, CYCLICAL	MOTION, LTD. EXCUR.	MOTION, CONCEPTUAL	COLOR	QUALITY	LOCALITY	SIZE/SHAPE/TEXTURE	TEMPERATURE	MOTION		SELECTION	SPECIFIC	CREATED	INDICATION	MANIPULATION	GROSS BODY MOVEMENT	INFORMATIVE	EVALUATIVE	CORRECTIVE	LINEAR	BRANCHING	ADAPTIVE	REPETITIVE
OVERHEAD TRANSPARENCIES	S	0	0	0	b	c	a	S	c	0	0	0	0	0	Z	Z	Z	Z	0	0	S	c	c	c	c	c	S
AUDIO TAPES	0	0	0	0	0	0	0	0	S	S*	0	0	0	0	Y*	Z	Z	0	0	0	S	S*	S*	c	S*	0	S*
2 X 2 SLIDES	S	0	0	0	a	e	f	S	d	0	0	0	0	0	Y*	Z	Z	Z	0	0	S	g	g	c	g*	c	S
SOUND SLIDES	S	0	0	0	a	c	f	S	S	0	0	0	0	0	Y*	Z	Z	Z	0	0	S	g*	g*	c	g*	0	S*
FILMSTRIPS	S	0	0	0	S*	S*	f	S	d	0	0	0	0	0	Y*	Z	Z	Z	0	0	S	g	g	c	g*	0	S*
SOUND FILMSTRIPS	S	0	0	S*	S*	S*	f	S	S	0	0	0	0	0	Y*	Z	Z	Z	0	0	S	c	c	c	0	0	S*
MOTION PICTURES	S	0	0	S	S	S	S	S	d	0	0	0	0	0	Z	Z	Z	Z	0	0	S	c	c	c	0	0	S*
SOUND MOTION PICTURES	S	0	0	S	S	S	S	S	S	0	0	0	0	0	Y*	Z	Z	Z	0	0	S	c	c	c	0	0	S*
MICROFORM	S	0	0	0	0	c	0	S	c	0	0	0	0	0	X*	Z	Z	Z	0	0	S	g	g	c	g*	c	S
TEACHING MACHINES	S	0	0	S*	S*	S*	S*	S*	S*	0	0	0	0	0	X	Z	Z	Z	0	0	S	S*	S*	S	S	0	S*
VIDEO RECORDING	S	0	0	S	S	S	S	S	S	0	0	0	0	0	Z	Z	Z	Z	0	0	S	c	c	c	0	0	S*
LIVE TELEVISION	S	0	0	S	S	S	S	S	S	0	0	0	0	0	Z	Z	Z	Z	0	0	S	c	c	c	0	0	0
SLOW SCAN TV	S	0	0	0	0	c	0	0	S	0	0	0	0	0	Z	Z	Z	Z	0	0	S	c	c	c	0	0	0
PRINTED MATERIAL	S	0	0	0	a	0	a	S	0	0	0	0	0	0	Z	Z	Z	Z	0	0	S	S	S	c	c	0	S
PROGRAMMED TEXT	S	0	0	0	a	0	a	S	0	0	0	0	0	0	X	X	X*	X*	0	0	S	S	S	S	S	0	S*
PAPER SIMULATIONS	S	0	0	0	0	0	0	S	0	0	0	0	0	0	X	Z	Z	X	0	0	S	S	c	S	S	0	0
CHARTS	S	0	0	0	0	c	0	S	c	0	0	0	0	0	Z	Z	Z	Z	0	0	c	c	c	c	c	0	c
DISPLAY BOARDS	S	0	0	0	0	c	0	S	c	0	0	0	0	0	Z	Z	Z	Z	Z	0	c	c	c	c	c	0	S
EC II	S	0	0	0	0	c	0	S	S	0	0	0	0	0	X	X	Z	X	0	0	S	S	c	S	S	c	S
AUDI/POINTER	S	0	0	0	0	S	S	S	S	0	0	0	0	0	X	X	Z	X	0	0	S	S	c	S	0	0	S
CPS 48	S	0	0	S	S	S	S	S	S	0	0	0	0	0	Z	Z	Z	Z	0	0	S	c	c	c	c	c	S
UNIVERSAL PROCESS TRAINER	S	0	0	0	0	S	S	S	c	0	0	0	0	0	0	0	0	X	X	0	S	S	c	c	c	c	S
MODELS/MOCKUPS	S	S	S	S*	S*	S*	S*	S*	c	0	S	0	S*	0	0	0	0	Z	Z	Z	c	c	c	c	c	0	S
BACK LIGHTED PANELS	S	e	0	0	S*	S*	S*	S*	c	0	e	0	e	0	0	0	0	X	X	0	S*	S*	c	S	S	0	S
ANIMATED PANELS	S	e	0	0	S*	S*	S*	S*	c	0	e	0	e	0	0	0	0	X	X	0	S*	S*	c	S	S	0	S
SIMULATORS	S	S	S	S*	S*	c	S*	S*	S*	S*	S	S*	S*	S*	0	0	0	X	X	X	S*	S*	c	S	S	S*	S
REALIA	S	S	S	S*	S*	c	S*	S*	S*	S*	S	S*	S*	S*	0	0	0	X	X	X	S*	S*	c	S	S*	c	S
COMPUTER ASSISTED INSTRUCTION	S	0	0	S*	S*	S*	S*	S*	S*	0	0	0	0	0	X	X	Z	X*	0	0	S	S	S	S	S	S	S

KEY

0	Not applicable, unsuitable
S	Generally suitable
a	Suitable when combined with visual motion adapters
b	Suitable when combined with visual motion adapters or projectable working models
c	Suitable only when used in conjunction with live instruction
d	Suitable when combined with audiovisual integrators
e	May contain certain three dimensional components such as real or oversize operating controls
f	Suitable when combined with dissolvers
g	Suitable when used in or combined with visual random access devices
X	Contains integrated response control of presentation
Y	Presentation can be controlled by separate response systems
Z	Presentation not controlled by response
*	Rating applies only to some devices in this category

FIGURE 6 (Reprinted by permission)

MEDIA REQUIREMENTS WORKSHEET	PRESENTATION														STUDENT RESPONSE						INSTRUCTIONAL STRATEGY						
	VISUAL								AUDITORY		TACTILE			KINESTHETIC CUES	VERBAL/ SYMBOLIC			PERFORMANCE			FEEDBACK			INTERACTION			
	PLANE (2D)	SOLID (3D)	LOCALITY (3D)	MOTION, FULL	MOTION, CYCLICAL	MOTION, LTD. EXCUR.	MOTION, CONCEPTUAL	COLOR	QUALITY	LOCALITY	SIZE/SHAPE/TEXTURE	TEMPERATURE	MOTION		SELECTION	SPECIFIC	CREATED	INDICATION	MANIPULATION	GROSS BODY MOVEMENT	INFORMATIVE	EVALUATIVE	CORRECTIVE	LINEAR	BRANCHING	ADAPTIVE	REPETITIVE

FIGURE 7 (Reprinted by permission)

The Kemp model (1975) uses the audience size as the primary selection decision. Desired learning experience levels, i.e., direct realistic, verbal, word abstraction, are secondary decisions. Tertiary is the sensory experience. Sequence charts evolved from this approach (Figure 8).

When the decisions point to a group of related media rather than a single type, the final selection is made on the basis of what is most practical (Figure 9).

Probably the most comprehensive media selection approach to date is that of Romiszowski (1974). Romiszowski uses an approach he has coined the "selection by rejection" algorithm.

As with all models, instructional objectives are stated initially (Figure 10).

Kemp, p. 78
Diagram withheld
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FIGURE 8a

Kemp, p. 78
Diagram withheld
pending publisher permission

FIGURE 8b

Kemp, p. 79
Diagram withheld
pending publisher permission

FIGURE 8c

Kemp, p. 81
Diagram withheld
pending publisher permission

FIGURE 9

Romiszowski, p. 66
Diagram withheld
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FIGURE 10

Instructional events are then prescribed to accomplish each objective. Third, the stimuli, response, and group size are considered (Figure 11).

Romiszowski, p. 68
Diagram withheld
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FIGURE 11

Essential media characteristics emerge through use of the learning task-media characteristic aids (Figures 12, 13, 14, 15).

Following through the flow charts, one should have a list of suitable media which satisfy the essential characteristics for stimulus, response, and group size. Further deletions are done systematically (Figure 16). Any remaining considerations yield further rejections (Figure 17).

By this time, only a few choices remain. The final decision is determined from how many objectives yielded the same medium and any teacher media preferences. The "make or buy" decision will also influence the final medium (Figure 10).

With this "selection by rejection" model, the outcomes are more predictable and repeatable than with less precise models (Romiszowski, 1974). The algorithmic approach leads directly to a prototype computer module under testing at this time (Bennion, 1977). By computerizing the

Romiszowski, p. 71
Diagram Withheld
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FIGURE 12

Romiszowski, p. 72
Diagram Withheld
Pending Publisher Permission

FIGURE 13

Romiszowski, p. 73
Diagram Withheld
Pending Publisher Permission

FIGURE 14

Romiszowski, p. 74-75
Diagram Withheld
Pending Publisher Permission

FIGURE 15

Romiszowski, p. 76
Diagram Withheld
Pending Publisher Permission

FIGURE 16

Romiszowski, P. 78
Diagram Withheld
Pending Publisher Permission

FIGURE 17

model, the designer need only attend to the decision blocks which pertain to the design under consideration.

The development of the media selection algorithm would seem to be the most useful model for designers dealing with the media selection process which, when done thoroughly, can become complicated.

Conclusion

As people concerned mainly with the development of computer-based instruction, we should recognize that we may be tempted to neglect media selection. Because the computer combines many of the capabilities of other extant device types and because the next generation of computers will have further expanded capabilities, we select CAI as the all-encompassing medium. But with a device capable of delivering so many modes of instruction, the designer must select the best mode.

We may be at the "select the appropriate media" stage with regard to CAI selection. Whether we can directly transfer the media selection models currently in the literature or whether we will develop still more models dealing directly with CAI is a subject for study. How will media mismatch be detected? This area is under research for all media selection.

These are some of the issues which designers of instruction and educational researchers are confronting and will continue to confront as the process of media selection strives toward precision and predictability.

REFERENCES

Alexander, M., & Hempstead, C. The media center. Topeka, Kansas: Kansas State Department of Education, 1976.

Allen, W. H. Media stimulus and types of learning. Audiovisual Instruction, January 1967.

Allen, W. H. What do 50 years of media research tell us? Audiovisual Instruction, March 1973.

Ausburn, L. J., & Ausburn, F. B. A supplantation model for instructional design: a preliminary investigation. Paper presented at the meeting of the Association of Educational Communications and Technology, Miami, Florida, 1977.

Bennion, B. Computerizing media selection. Unpublished manuscript, University of Iowa, 1977.

Boucher, B., Gottlieb, M., & Morganlander, M. Handbook and catalog for instructional media selection. Englewood Cliffs, New Jersey: Educational Technology Publications, 1973.

Cavert, C. E. An approach to the design of mediated instruction. Washington, D.C.: Association of Educational Communications and Technology, 1974.

Cochran, L. M. Toward a theory of visual stimuli. Unpublished manuscript, University of Iowa, 1976.

Diamond, R. M. Piecing together the media selection jigsaw. Audiovisual Instruction, January 1977.

Dick, W., & Gallagher, P. Systems concepts and computer-managed instruction: an implementation and validation study. Educational Technology, February 1972.

Gagné, R. M., & Briggs, L. J. Principles of instructional design. New York: Holt, Rinehart, and Winston, 1974.

Gilbert, T. F. Mathetics: the technology of education. Journal of Mathetics, 1962, 1, 7-73. In D. Merrill (Ed.), Instructional design: readings. Englewood Cliffs, New Jersey: Prentice-Hall, 1971.

Gropper, G., Glasgow, Z., & Klingensmith, J. Criteria for selection and use of visuals in education. Englewood Cliffs, New Jersey: Educational Technology Publications, 1977.

Hug, W. Instructional design and the media program. Chicago: American Library Association, 1975.

Hunter, B., Kastner, C., Rubin, M., & Seidel, R. Learning alternatives in U.S. education: where student and computer meet. Englewood Cliffs, New Jersey: Educational Technology Publications, 1975.

Kemp, J. E. Planning and producing audiovisual materials. New York: Thomas Y. Crowell Co., 1975.

Kemp, J. E. Instructional design: a plan for unit and course development. Belmont, California: Fearon Publishers, 1977.

Moses, K., & Watt, L. Aids to media selection for students and teachers. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1976.

Policies and procedures for selection of instructional materials. School Media Quarterly, Winter 1977.

Romiszowski, A. J. Selection and use of instructional media: a systems approach. New York: John Wiley & Sons, 1974.

Simonson, M., & Burch, G. Media influence on affective learning: a review of the literature. Paper presented at the meeting of the Association of Educational Communications and Technology, Miami, Florida, March 1977.

Solomon, G., & Cohen, A. The effects of television formats on mental skills. Paper presented at the Conference on Visual Literacy, Nashville, Tennessee, March 1976.

Storm, S. R. Preference for visual, aural, or audiovisual treatment in ten educational settings as a variable in ATI research. Paper presented at the meeting of the Association of Educational Communications and Technology, Anaheim, California, April 1976.

Tosti, D., & Ball, J. A behavioral approach to instructional design and media selection. AV Communication Review, Spring 1969.

Weinthaler, J., & Rotberg, J. The systematic selection of instructional materials based on an inventory of learning abilities and skills. In B. & R. Mills (Eds.), Designing instructional strategies for young children. Dubuque, Iowa: Wm. C. Brown, 1972.

ODU-CAUSE: COMPUTER BASED LEARNING LAB

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*

The purpose of this paper is to describe the Computer Based Learning Lab at Old Dominion University as a component of the ODU-CAUSE Project. Emphasis is directed to the structure and management of the facility and to the software under development by the staff of the facility.

The ODU-CAUSE Project is a response to the unique educational problems of a growing urban university and of its students as identified by the faculty of the School of Sciences and Health Professions. A typical profile of one of Old Dominion University's 14,000 students is one who commutes to school and has additional responsibilities involving employment and family. The institution has doubled in size since 1969 when it became the regional university of eastern Virginia, and consequently it is short of adequate funding, space, and facilities.

The major educational problems that the ODU-CAUSE Project is helping to solve are as diverse as the faculty and student body it serves. Among these problems are: basic mathematics skill deficiencies and consequently high withdrawal/failure rates in fundamental science courses; lack of personalized instructional facilities; difficulty in managing the records and rolls in large lecture sections (350 students per section is common); no educational graphics facilities and personnel and a very limited audio/visual equipment and software inventory; insufficient computer facilities (hardware and software) coupled with a small educational programming staff; and a complete lack of evaluation of educational techniques and outcomes.

In order to solve these problems the three year ODU-CAUSE Project has been funded by the university (56%) and the National Science Foundation (44%) for a total of $682,906.00. The NSF funds come under the auspices of their program for Comprehensive Assistance to Undergraduate Science Education (CAUSE). The project has four basic components: the Learning Resource Center (LRC); the Computer Based Learning Lab (CBLL); the Steering Committee; and the User Group. The Steering Committee directs the activites of the project and is composed of faculty from the various schools meeting with the directors of the Computer Center, the Instructional Media Center, the Center of Institutional Development and a representative from the Student Senate. In addition to staffing responsibilities and project leadership, the Steering Committee funds individual faculty projects (the User Group) in a way consistent with solving the educational problems of the institution.

The LRC was created as a means by which students on their own schedule may review and study course materials, remediate deficiencies and take achievement examinations. The CBLL design is patterned after a similar facility developed at the University of Wisconsin-Milwaukee and is charged with assisting the faculty User Group in the use of educational technology in such a way as to provide solutions to the problems encountered by that group.

The CBLL and LRC were established in January, 1977 in adjoining offices. The proximity of this arrangement allows for single management of both facilities and is also beneficial due to the combined use of the CBLL and the LRC in activities being carried out by members of the User Group. The CBLL is staffed by a lead programmer/analyst, two programmers, a graphics illustrator, and an administrative secretary. The lead programmer/analyst is responsible for management of the facility and direction of the programmming activities of the CBLL. In addition, student assistants are employed to monitor use of the LRC and for data input requirements of the CBLL. Serving the ODU-CAUSE User Group with respect to their programming needs is a predominate role of the CBLL; however, the CBLL is also responding to the needs of the university in several other ways.

The CBLL is becoming known as a university-wide resource center for educational computing. Periodicals and proceedings from various educational sources are housed in the CBLL and are available for inspection by the university faculty. Also on hand are materials describing available educational courseware (i.e., Wang's INDEX TO COMPUTER-BASED LEARNING and CONDUIT materials). The programming staff supplies assistance in identifying, transporting and implementing available courseware for interested faculty. It is worthwhile noting that faculty do not need to possess programming experience to use available courseware. The CBLL staff provides the technical interface necessary to utilize educational computer technology.

The ODU-CAUSE Project is also committed to the implementation of computer graphics as an educational resource. An electrostatic printer/plotter was purchased with project funds for use by the User Group and the university. The CBLL staff is working in conjuction with the staff of the Computer Center in implementation of the graphics software and in adding the device to the computer system.

ODU's Computer Center has a Digital Equipment Corporation DECsystem-10 which serves as the principle computing facility for administrative, research, instructional and educational users at the university. The installation is in a period of growth and development which, unfortunately, is lagging behind the current demand for its services. The CBLL objectives of implementation of computer assisted instruction (CAI) and computer managed instruction (CMI) accentuate the necessity for expansion of the installation which currently supports a maximum of 45 time-sharing users and 5 batch jobs . The project is hopefully serving as a catalyst in this effort through the major funding of a disk drive, the printer plotter, additional time-share ports, and an optical reader. The optical reader has proved to be an important resource for the entire university by providing a great improvement in the capability for machine read surveys and examinations. The limitations of the installation have put restraints on the implementation of CAI courseware; thus emphasis in program development is toward software which can be used within the current configuration. Implementation of a computer managed instruction system was considered feasible within the given constraints and a CMI system satisfied a project goal of providing an alternative form of class record management.

INTERACTIVE COMPUTER MANAGED INSTRUCTION

A group of programs were developed in 1975 by Dr. G. E. Copeland to provide general statistics, histograms, and updating of scores entered on a course roll file. These programs were used as the base in the development of the ODU-CAUSE CMI system. It was desired to make the programs accessible to a large number of faculty. Execution of the programs by the instructors themselves was considered essential for the CMI system to become a viable alternative to course record management on a large scale. In addition, the system had to be easy to operate to make it accessible to the instructor who was a novice user of the computer. The ease of access and execution desired was accomplished in two ways. First, extensive error proofing of inputs during the user dialog minimized user entry errors. Secondly, the development of a control program greatly reduced the complexity of an interactive CMI session. The control program allows execution of any of the components of the CMI system as a functional input to the program. Thus, an instructor needs only to execute the control program during an interactive session to perform a number of the CMI functions. The control program was made possible by the 'CHAIN' command of BASIC-PLUS which allows execution of a BASIC program called during execution of another BASIC program.

An important aspect of the CMI system is the interface with computer scored testing. Instructors opting for examinations using multiple choice, true-false, or list matching can have the answer sheets optically scanned and computer scored. A disk file created during computer scoring containing student identification and scores can then be merged into the course roll file using the CMI system . This is particularly useful for large classes where data input of scores may be a significant factor in considering adoption of a CMI system of grade management.

Another useful characteristic of the CMI system is related to its interactive nature. The system is designed to be run on-line from either a hardcopy terminal or from a CRT. A hardcopy terminal creates a paper copy of the desired output but printing is generally slow. The CRT terminal outputs information at a faster rate but does not create a paper copy. To account for the differences in the available terminals and to accentuate the advantages of each, the CMI system outputs requested information at the user's discretion either to the user terminal or writes the information to a disk file for later output on a fast line printer.

UTILIZATION and COMMENTS

In the spring, 1977 semester 9 instructors utilized the CMI system to manage grades in 15 classes affecting 1000 students. Utilization has more than doubled during the second semester of the CMI system's availability. Although a comprehensive utilization study has not been undertaken, the reaction of faculty who have used the system has been favorable. Feedback to the CBLL staff has included many recommendations on how the system might be improved; most of these recommendations have been added to the system. The criteria used in modifying the system is in determining if the changes will have general use by others as opposed to a specific use by a single user. Repeat usage of the system by most of the original users is another indication of general acceptance of the system. Although we are noting moderate success in acceptance of the CMI system, there are problems which must be overcome before the system will become a widely used resource.

We noted earlier that the status of the installation limited our approach to CAI activities. The installation also is having a direct effect on the CMI system utilization. A common complaint by users is that during peak usage hours (9 am to 6 pm) the computer is running at full job capacity and no other time-share users may gain access to the machine. Easy access was considered a requirement for the success of the system and nonavailibility of the computer during the business day is having a direct effect on utilization. The favorable attitude concerning the system has come from faculty who have accepted the limitations of the computer and use the system during off hours. Faculty with little or no computer experience must be comfortable with how to gain access to and use the CMI system for them to accept it for their course record management. This requires some training in how to use a terminal, how to gain access to the computer, how to execute the CMI system, and how to maintain their computer disk areas which contain their records. The ODU-CAUSE Project has sponsored workshops to acquaint faculty with the CMI system and the CBLL provides personal assistance and documentation of the system. It remains for the faculty member to accept the CMI system as an educational resource and make the time necessary to become familiar and comfortable with how to use the system.

In the following example we illustrate the flexibility and functional structure of the CMI system as we add a set of scores from a machine scored test; add a set of scores from terminal input; create a histogram of the first test; and modify a student record in the roll file.

ODU-CAUSE: CBLL

THE FOLLOWING FILE (COURSE.ROL) IS AN EXAMPLE OF A COURSE ROLL FILE NECESSARY AS INPUT TO THE CMI SYSTEM.

```
01000    "SAMPLE-CLASS                 "
01010    14
01020    0
01030    147-39-6521 "BROWN J "
01040    001-32-2310 "BURNS JE"
01050    117-43-6932 "DORIGHT D "
01060    229-68-3312 "ELLSWOOD J "
01070    111-22-3333 "GREEN WA"
01080    340-98-6514 "JOHNSON R "
01090    230-88-9988 "KELLY L "
01100    581-73-9125 "RICHARDS M "
01110    342-16-9383 "RONI M "
01120    623-84-9989 "SMITH A "
01130    121-01-4890 "WELLS S "
01140    321-54-9876 "WILLIAMS W "
01150    121-77-8047 "WOOD JO"
01160    340-11-2301 "YOUNG P "
```

THE FOLLOWING FILE (ST2116.294) IS A SAMPLE OF THE GRADE FILE CREATED FROM SCORING AN OPSCAN READ EXAMINATION. THE COLUMNS CONTAIN THE RAW SCORE, ABSOLUTE SCORE, RELATIVE SCORE AND STANDARD SCORE, RESPECTIVELY.

```
BROWN       JOHN   147396521     5    50.0   50.0        405
BURNS       JOY  E 001322310     5    50.0   50.0        405
DORIGHT     DUDLEY 117436932    10   100.0  100.0        738
ELLSWOOD    JEAN   229683312     5    50.0   50.0        405
GREEN       WILLIA 421384221     7    70.0   70.0        538
JOHNSON     ROBERT 340986514     7    70.0   70.0        538
KELLY       LISA   230889988     5    50.0   50.0        405
RICHARDS    MARTHA 581739125     8    80.0   80.0        605
RONI        MAC    342169383     8    80.0   80.0        605
SMITH       ALLEN  623849989     5    50.0   50.0        405
WELLS       SUSAN  121014890     5    50.0   50.0        405
WILLIAMS    WILL   321549876     7    70.0   70.0        538
WOOD        JIM  O 121778047     7    70.0   70.0        538
YOUNG       PHIL   340112301     6    60.0   60.0        471
```

```
    .R BASIC
READY, FOR HELP TYPE HELP.
       OLD BAS:ROLPRG.CMI
READY
       RUN
ARE YOU FAMILIAR WITH THIS SYSTEM ?
       NO
THIS SYSTEM IS A SERIES OF PROGRAMS DESIGNED TO
MAINTAIN AND ANALYZE A ROLL FILE. THE PROGRAMS
AVAILABLE ARE;
ALPHA   - ALPHABETIZE ROLL FILE
UPDATE  - TO ADD A SET OF SCORES TO THE
                ROLL FILE FROM THE TERMINAL.
MODIFY  - ALLOWS COMPREHENSIVE EDITING
                OF A ROLL FILE.
RANK    - CREATE A LISTING OF THE ROLL
                FILE SORTED ACCORDING TO THE
                USER'S REQUESTS.
TESAVG  - GENERATE SCORE AVERAGES OR
                SUM STRING OF SCORES ON ROLL FILES.
STATNW  - USED AFTER TESAVG TO PROVIDE
                STATISTICAL INFO ON STUDENTS'
                SCORES AND AVERAGES.
HISTGR  - PRINT HISTOGRAMS OF STUDENT
                SCORES FROM ROLL FILE.
MERGE   - TO ADD A SET OF SCORES TO THE
                ROLL FILE FROM AN OPSCAN
                CREATED FILE (ST FILE).
FILES   - CREATE/UPDATE A ROLL FILE WITH SCORES FROM
                ANOTHER ROLL FILE
ROLPRG  - THIS PROGRAM.  IT IS DESIGNED
                TO ALLOW THE USER TO USE THE
                ABOVE PROGRAMS WITHOUT EXTENSIVE
                COMPUTER EXPERIENCE.

THE FOLLOWING PROGRAMS ARE ALSO AVAILABLE
ROLGEN  - FORTRAN PROGRAM TO CREATE
                INITIAL ROLL FILE FROM AN OPSCAN
                CREATED FILE.
FMAKE   - FORTRAN PROGRAM TO CREATE ROLL
                FROM ENROLLMENT RECORDS

DO YOU NEED INFO ABOUT THE ROLL FILE FORMAT ?
       YES
THE ROLL FILE IS A LINE-NUMBERED FILE THAT
CONTAINS 1 OR MORE LINES PER STUDENT PLUS 3 LINES
AT THE BEGINNING THAT CONTAIN INFO ABOUT THE FILE.
LINE1 - COURSE-NAME
LINE2 - NUMBER OF STUDENTS
LINE3 - NUMBER OF SCORES PER STUDENT
LINE4 - DESCRIPTION OR FIRST SCORE ON FILE
...............
...............
LINE(4+N) - DESCRIPTION OF N'TH SCORE ON FILE
```

```
FOR     ! STUDENT NUMBER  "STUDENT NAME"
EACH    !       SCORE 1 ... SCORE N
STUDENT !
WHERE STUDENT NUMBER HAS FORM NNN-NN-NNNN
AND STUDENT NAME HAS FORM "LASTNAME FM"
(F=FIRST INITIAL, M=MIDDLE INITIAL)


THE ROLL FILE CAN BE CREATED USING ANY LINE-ORIENTED
TEXT EDITOR (SUCH AS BASIC'S) OR BY USING THE ROLGEN
OR FMAKE PROGRAMS

THE COMMANDS TO PERFORM VARIOUS
FUNCTIONS ARE;
HELP    - FOR THIS LIST
ALPHA   - ALPHABETIZE ROLL FILE
UPDATE  - TO ADD SCORES (BY HAND)
MODIFY  - TO EDIT ROLL FILE
RANK    - TO SORT AND LIST
TESAVG  - TO GENERATE AVERAGES
STATNW  - TO PROVIDE STATISTICS
HISTGR  - TO GENERATE HISTOGRAMS
MERGE  - MERGE OPSCAN GRADED FILE (ST?.? FILE)
FILES   - CREATE/UPDATE A ROLL FILE FROM ANOTHER ROLL FILE
STOP    - EXIT FROM SYSTEM


PLEASE INPUT ROLL FILE NAME ?
       COURSE.ROL


FUNCTION: ?
       MERGE
INPUT A NAME FOR THE FILE CONTAINING MATCH ERRORS       ?
       MERGE.ERR
INPUT THE NAME OF THE OPSCAN GRADE FILE ?
       ST2116.294
INDICATE WHICH GRADE YOU WISH TO MERGE FROM THE FILE:
TYPE    1 FOR RAW SCORE
        2 FOR ABSOLUTE SCORE
        3 FOR RELATIVE SCORE
        4 FOR STANDARD SCORE    ?
       2

CLASS NAME IS SAMPLE-CLASS
14  STUDENTS ARE ON THE ROLL
0  GRADES ARE CURRENTLY ON THE ROLL

INPUT (<=72 CHAR) DESCRIPTION OF TEST BEING MERGED      ?
       SAMPLE TEST 1

REMEMBER - MATCH ERRORS ARE CONTAINED IN FILE MERGE.ERR

EXIT FROM MERGE
```

ODU-CAUSE: CBLL

```
       FUNCTION: ?
              UPDATE

       UPDATE - ADD TEST GRADES TO ROLL FILE

       THE CLASS IS SAMPLE-CLASS
       THERE ARE  14 STUDENTS
       THERE ARE  1  TESTS ALREADY ON THE GRADE BOOK

       DO YOU WANT TO ADD GRADES (YES OR NO) ?
              YES
       HOW MANY GRADES TO BE INPUT FOR EACH STUDENT    ?
              1
       INPUT (<= 72 CHAR) DESCRIPTION OF GRADE  1  TO BE ENTERED
     ?
              SAMPLE TEST 2

       NOW WE MUST ADD IN THE GRADES FOR EACH STUDENT
       I WILL GIVE THE STUDENT NAME ;HIS TEST SCORES AND A ?
       THEN ENTER THE NEW SCORE(S) AND <RETURN>
       IF NO TEST ENTER -1

       BROWN J                  50  ?          60
       BURNS JE                 50  ?          65
       DORIGHT D               100  ?          95
       ELLSWOOD J               50  ?          85
       GREEN WA                 -1  ?          70
       JOHNSON R                70  ?          70
       KELLY L                  50  ?          70
       RICHARDS M               80  ?          80
       RONI M                   80  ?          90
       SMITH A                  50  ?          60
       WELLS S                  50  ?          65
       WILLIAMS W               70  ?          85
       WOOD JO                  70  ?          60
       YOUNG P                  60  ?          80

       EXIT FROM UPDATE
```

```
ODU-CAUSE: CBLL

        FUNCTION: ?
               HISTGR

        HISTGR - CREATES HISTOGRAMS FROM CLASS ROLL

        CLASS IS SAMPLE-CLASS
        THERE ARE  14  STUDENTS
        THERE ARE 2 GRADES ON THE ROLL

        FOR WHICH TEST DO YOU DESIRE A HISTOGRAM
        INPUT 0 FOR HISTOGRAM OF AVERAGE SCORE FROM TESAVG      ?
               1
        DO YOU WANT TO SAVE THE OUTPUT IN A DISK FILE ?
               NO
        INPUT INCREMENT BETWEEN UNITS FOR THIS HISTOGRAM        ?
               5


        SAMPLE TEST 1
        SCORE          NUMBER OF PEOPLE              TEST NUMBER 1
        50            ******
        55
        60            *
        65
        70            ***
        75
        80            **
        85
        90
        95
        100           *
        1 PEOPLE DID NOT RECEIVE GRADES
        0 PEOPLE RECEIVED ZERO GRADES
        DO YOU WISH TO CREATE ANOTHER HISTOGRAM ?
               NO

        EXIT FROM HISTGR

        FUNCTION: ?
               STOP
        READY
              MONITOR

              TYPE MERGE.ERR

        THESE STUDENTS ARE IN THE GRADE FILE ONLY
        421384221    GREEN WILLIA A                   70
        THESE STUDENTS WERE IN THE ROLL FILE
        111-22-3333    GREEN WA                  -1

              MATCH ERRORS ARE CORRECTED USING THE MODIFY FUNCTION
```

ODU-CAUSE: CBLL

```
FUNCTION: ?     MODIFY
MODIFY - ROLL FILE EDITOR
ARE YOU FAMILIAR WITH THIS PROGRAM ?    NO

THIS PROGRAM ALLOWS THE USER TO
EDIT A ROLL BOOK FILE.
CAPABILITIES INCLUDE -
1) ADD/DROP STUDENTS
2) MODIFY RECORDS
ALL THE FUNCTIONS WORK ON THE
BASIS OF THE STUDENT NUMBER
OR NAME AND THE PROGRAM PROMPTS
THE USER FOR ADDITIONAL INFO.

MODIFY FUNCTIONS INCLUDE:
HELP     - FOR THIS LIST
LIST     - LIST A STUDENT ENTRY
ADD      - ADD A STUDENT
DROP     - DROP A STUDENT
CHANGE   - TO CHANGE PART OF A STUDENT RECORD
STOP     - TO WRITE OUT UPDATED FILE AND EXIT

ABBREVIATIONS FOR FUNCTION NAMES ARE ACCEPTABLE
THE ARGUMENT FOR A FUNCTION MAY BE TYPED ON
THE SAME LINE AS THE FUNCTION NAME.

CLASS NAME IS SAMPLE-CLASS
14 STUDENTS ARE ON THE ROLL
2 GRADES ARE CURRENTLY ON THE ROLL FILE

MODIFY: ?       CHANGE
CHANGE:STUDENT NAME, NUMBER, OR STOP ?
GREEN WA
111-22-3333   GREEN WA      -1  70
CHANGE ?        H
TYPE;
H FOR HELP
N TO CHANGE NAME
S TO CHANGE NUMBER
G TO CHANGE A GRADE
Q TO FINISH
CHANGE ?        S
STUDENT NUMBER ?        421384221
CHANGE ?        G
WHICH GRADE (1 - 2 ) ?  1
INPUT GRADE ?   70
CHANGE ?        Q
421-38-4221   GREEN WA       70  70
CHANGE:STUDENT NAME, NUMBER, OR STOP ?
STOP
MODIFY: ?       STOP

EXIT FROM MODIFY
```

LEARNER CONTROL OF COMPUTER-BASED INSTRUCTION: A comparison to guided instruction

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Following Mager's findings (Mager, 1961; Mager and McCann, 1961; Mager and Clark, 1963) that student control of the learning situation facilitates learning, learner control has been applied for study in a variety of settings. Researchers have investigated its utility in the classroom and in computer-based instruction (CBI). In an analysis of the possible advantages of learner control, Merrill (Merrill, 1973; Merrill and Boutwell, 1971) theorized that learner control would be instrumental in the acquisition of learning strategies that optimize the student's learning process, and that make the learner independent of rather than dependent on the teacher's strategies. However, in their reviews of the literature, Judd, O'Neil and Spelt (1974) and Steinberg (1977) find a fairly consistent pattern of no differences in test performance after training, and only parsimonious indication of long-term effects.

In an earlier study of the use of learner control in two CBI lessons (Lahey and Crawford, 1976), we found no evidence that students were switching to a 'learned' strategy, nor that selection of one strategy over another significantly affected lesson performance. This led us to question whether strategies would change if the time were extended, and whether learner control students would do better if they were given advice as to what type of lesson content to see next. We also wanted to test whether learner control was superior to adaptive programmed control. This paper describes then a research study in which we compared the effects of learner control to learner control with advice as to what content to see next and to programmed control.

Method

Students in training at the Basic Electricity/Electronics School, Service Command, Naval Training Center, San Diego served as subjects in this study. The lesson materials used for the study were four lessons on using a multimeter, one on measuring resistance (hereafter called the ohms lesson), one on measuring DC current flow (hereafter called the amps lesson), one on voltage in series circuits (voltage) and one on measuring DC and AC voltages (volts). Between the first and second lessons, the students took a hands-on performance test using the multimeter as an ohmmeter, and a module examination covering resistances and resistance measurement. Following the fourth lesson, the students took a hands-on performance test using the multimeter to measure current flow and voltages and a module examination covering current flow and voltage in series circuits.

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[1] The research effort described in this paper was supported as part of an Advanced Research Projects Agency/Joint Services Training Technology Program for development of computer-based training technology. The position and opinions reflected in this paper are those of the author and do not reflect an official Navy position.

Students were assigned randomly to one of three treatment modes; learner control, learner control with guidance, or programmed control. The treatments were essentially as follows:

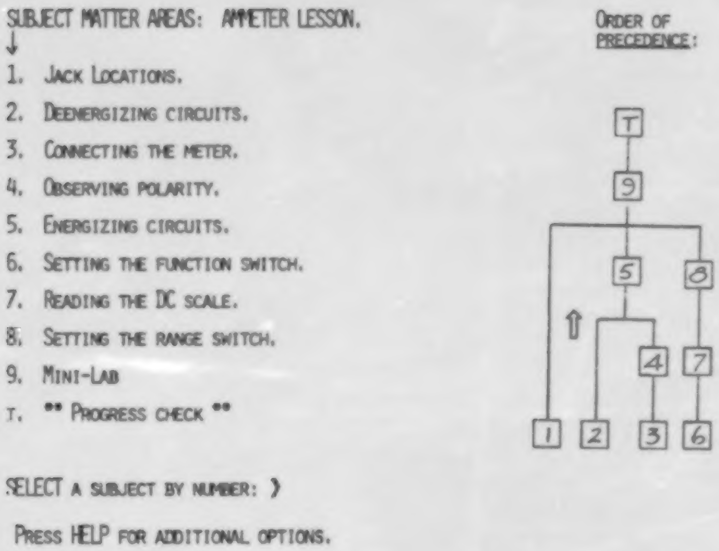
The learner control mode used in this study was essentially that described in Lahey, Crawford, and Hurlock (1976), wherein the student is free to choose individual lesson segments and content within lesson segments without restrictions on the order in which he sees individual materials or on how often he sees them. The individual lesson segments contain rules, examples, practice problems, and expository helps at easy, medium, and hard levels of difficulty. The student choses lesson segments from an index such as that shown in Figure 1, then chooses lesson content selectively, as is indicated in Figure 2. The option block presented at the bottom of each individual frame of the lesson content lets the student choose what he will see next by pressing the PLATO IV touch panel. To prevent fixation on a particular order, the relative positions of the rule, examples and practice option blocks are randomly varied for each presentation.

The second form of the learner control mode used an unobtrusive arrow superimposed on the lesson index or content choice page to recommend which lesson segment or lesson content the student should select next. The basic parameters used for guidance were a numerical sequence of lesson segments, and a rule-example-practice sequence of lesson content. The guidance function parameters for lesson content were however adaptive, as is indicated in Figure 3. The guidance function in essence asked, "What is the student seeing now?" and "What has he previously seen?", then it selected a recommendation based on his progress to date. Students in the guided learner control mode could start a lesson segment at the easy, medium, or hard level of difficulty with either the rules, an example, or a practice problem. After they had made a free initial choice, the guidance function (Advisor) came into play to recommend what to select next.

The programmed control mode imposed the same guidance parameters prescribed for the guided group but without choice. Programmed control students started out at the medium level of difficulty rule, followed by examples, and followed by practice problems. Their subsequent history depended explicitly on their success/failure history with the medium level practice problems. Failure to correctly answer practice problems could conceivably take the student to the easy rule, from whence he would have to work his way back to successful completion of the hardest practice problems in that lesson segment before going on to the next lesson segment. All branching was computer controlled, with no options given.

Results and Discussion

The performance data of the three experimental groups are presented in Table 1. There were no significant differences in performance between the three groups. Only the number of responses made during the initial lesson (ohms) and the short third lesson (voltage) differed significantly for the programmed control group. These differences were due primarily to the fact that the learner control students could opt for easy level content while the programmed control students could not.



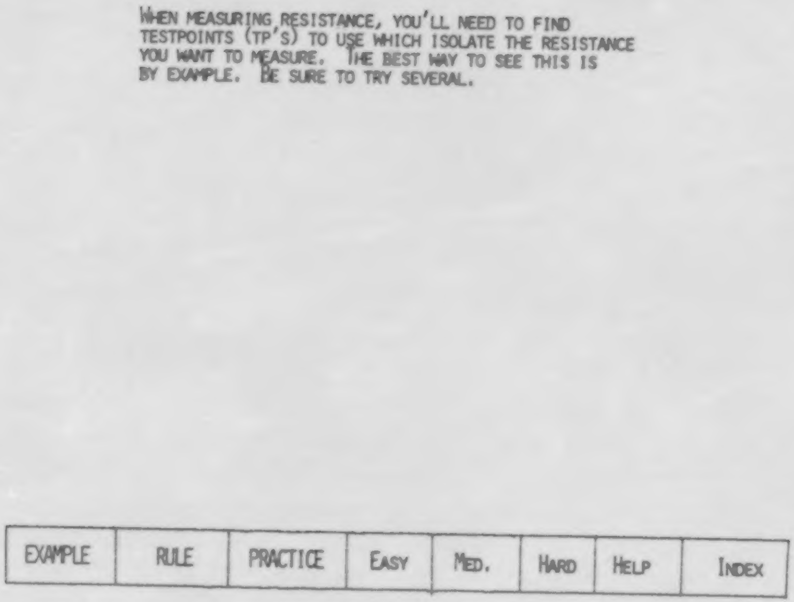
SUBJECT MATTER AREAS: AMMETER LESSON.
↓
1. JACK LOCATIONS.
2. DEENERGIZING CIRCUITS.
3. CONNECTING THE METER.
4. OBSERVING POLARITY.
5. ENERGIZING CIRCUITS.
6. SETTING THE FUNCTION SWITCH.
7. READING THE DC SCALE.
8. SETTING THE RANGE SWITCH.
9. MINI-LAB
T. ** PROGRESS CHECK **

SELECT A SUBJECT BY NUMBER: ❯

PRESS HELP FOR ADDITIONAL OPTIONS.

ORDER OF PRECEDENCE:

Figure 1. Learner Index, amps lesson



WHEN MEASURING RESISTANCE, YOU'LL NEED TO FIND TESTPOINTS (TP'S) TO USE WHICH ISOLATE THE RESISTANCE YOU WANT TO MEASURE. THE BEST WAY TO SEE THIS IS BY EXAMPLE. BE SURE TO TRY SEVERAL.

EXAMPLE
RULE
PRACTICE
EASY
MED.
HARD
HELP
INDEX

Figure 2: Sample Objective Page, Ohms Lesson.

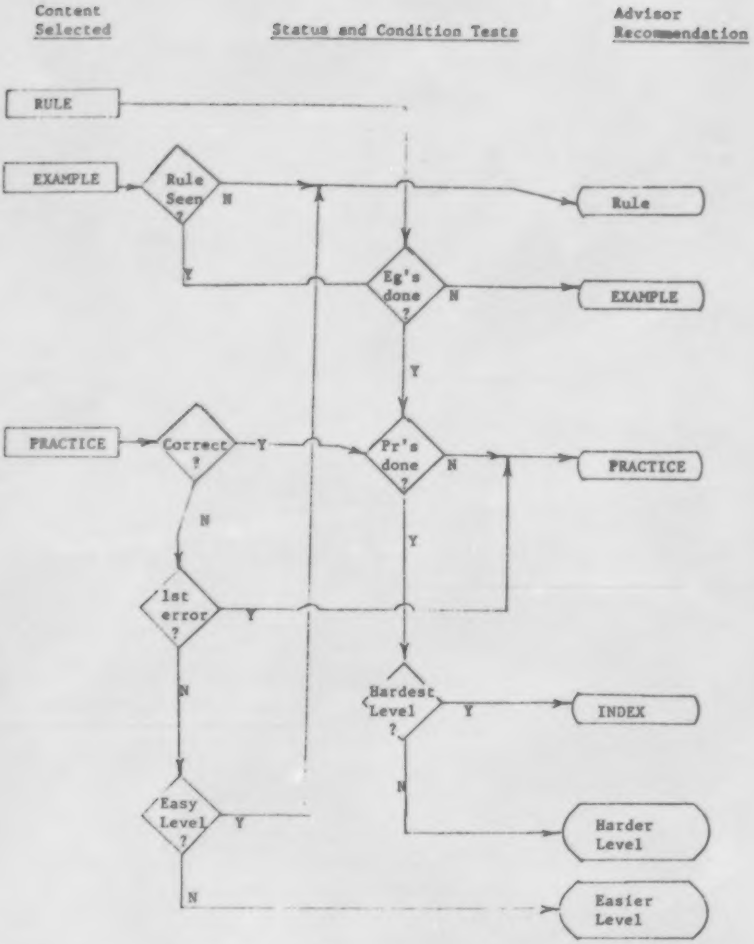

Content Selected
Status and Condition Tests
Advisor Recommendation
RULE
EXAMPLE
Rule Seen ?
N
Y
Rule
Eg's done ?
N
EXAMPLE
Y
PRACTICE
Correct ?
Y
Pr's done ?
N
PRACTICE
N
Y
1st error ?
Y
N
Hardest Level ?
Y
INDEX
N
Easy Level ?
Y
Harder Level
N
Easier Level

Figure 3: Advisor Subroutine

Table I

Overall Performance Analysis

	Learner Control	Advisor	Programmed Control	Controls
Ohms lesson:				
Test score (%)	80.1	81.0	84.6	--
No. responses	216	231	163*	—
Time (hrs)	2:05	2:14	1:49	
Module 3:				
Trials, perf. test	1.1	1.4	1.3	1.2
Errors, mod. exam	2.4	2.1	2.3	1.7
Amps lesson:				
Test score (%)	72.3	66.1	73.0	--
No. responses	249	243	204	--
Time (hrs)	1:57	1:59	1:46	--
Voltage lesson:				
Test score (%)	93.6	95.1	95.5	--
No. responses	68	65	47**	--
Time (hrs)	0:26	0:26	0:22	--
Volts lesson:				
Test score (%)	85.6	88.8	87.3	--
No. responses	215	230	217	--
Time (hrs)	1:41	1:52	1:45	—
Module 4:				
Trials, perf. test	1.8	1.8	1.6	1.7
Errors, mod. exam	0.8	0.9	1.0	0.8

* $p < .01$, ** $p \leqslant .001$

It was necessary to confirm that the strategies used within the three treatment groups were indeed different, since learner control could have little impact if it resulted in the same training sequences as were used in the programmed control mode. Therefore, the individual paths taken by each student were examined to confirm that the groups used different lesson strategies. We found that the guided group had selected lesson segments in order more frequently than the learner control group in all four lessons, df = 1, χ^2 in excess of 7.0, $p<.01$, and less frequently than the programmed control group in three of the lessons, df = 1, χ^2 greater than 7.2, $p<.01$. In the short third lesson, 43 of the 44 guided students chose the 4 lesson segments in the numerical sequence.

The guided students also selected strategies recommended by the guidance function (Advisor) more often than the unguided group df = 1, $\chi^2 = 31.09$, $p<.01$ and less often than the programmed control group, df = 1, $\chi^2 = 13.9$, $p<.01$. The analysis confirms that the treatments included differences in the lesson strategies used which presumably could have resulted in differences in lesson performance. As in our previous study (Lahey and Crawford, 1976), there was no evidence of switching to a learned strategy during the later lessons for either of the learner control groups.

In an a posteriori analysis of the data it was found that learner control students who adopted a rule-example-practice strategy did better on three of the four lesson tests than those who did not: df = 1, 80; MSW = 175.4 and F = 8.10 in the ohms lesson, MSW = 7.15 and F = 80.0 in the voltage lesson, and MSW = 29.8 and F = 80.0 in the volts lesson; all significant at the .01 level. There was no significant difference between the performance of the a posteriori groups during the amps lesson, perhaps because of the difficulty of this lesson. The performance of the a posteriori groups is presented in Table 2. The performance of the a posteriori rule-example-practice group did not differ from that of the programmed control treatment group in any of the lessons.

Following completion of the lessons, each student was asked to fill in an attitude questionnaire. Analysis of this questionnaire indicated no significant difference in the attitude towards computer-based instruction as a result of the different treatments.

The results are consistent with an expectation that students tend to follow the instructor's guidance, though they are capable of choosing other paths. The results also seem to indicate that learner control has no immediate pedagogical advantage over adaptive programmed control. Moreover, giving the learner control guidance, while effective in directing the path students take through the lesson, does not significantly reduce the time they spend in the lesson nor constructively reduce number of responses made.

Table 2

Lesson Test Performance as a Function of Strategy Selection, Collapsed Over Learner Control and Advisor Groups

	Dominant Strategy	
Lesson	Ru-Eg-Pr	Other
Ohms	83.5	74.9*
Amps	71.2	68.1
Voltage	96.2	91.5*
Volts	88.2	77.1*
Number of students	51	31

* $p < .01$

Conclusions

The results suggest that learner control, guided or unguided, may have no significant pedagogical advantage over adaptive programmed control. It also appears that the motivational advantage presumed in earlier studies may have been primarily a function of the novelty of the presentation, since in this study all three modes were novel and all three modes seemed to be received equally enthusiastically. However, while it appears not to offer an immediate pedagogical advantage to the student, the learner control mode of instruction may be chosen in the long run for other reasons, such as economy of lesson development or, if proven, for the long-term effects postulated by Merrill (1973).

References

Judd, W. A., O'Neil, H. H., Jr., and Spelt, P. F. Individual differences and learner control 1: Program development and investigation of control over mnemonics in computer-assisted instruction (AFHRL Tech. Rep. 74-3). Lowry AFB: Air Force Human Resources Laboratory, July 1974.

Lahey, G. F. and Crawford, A. M. Learner control of lesson strategy: Some tentative data. Paper presented at annual meeting of American Educational Research Association, San Francisco, California, April 1976.

Lahey, G. F., Crawford, A. M., and Hurlock, R. E. Learner control of lesson strategy: A model for PLATO IV System lessons (NPRDC Tech. Rep. 76-36). San Diego: Navy Personnel Research and Development Center, June 1976.

Mager, R. F. and Clark, C. Exploration in student controlled instruction. Psychological Reports, 13, 1963.

Mager, R. F. and McCann, I. Learner controlled instruction. Palo Alto, CA: Varian Associates, 1961.

Merrill, M. D. Premises, propositions, and research underlying the design of a learner controlled computer-assisted instructions system: A summary for the TICCIT System Provo, Utah: Brigham Young University, June 1973.

Merrill, M. D. and Boutwell, R. C. Instructional development: Methodology and research. In Berlinger, F. N. (Ed.) Review of research in education. Itasca, Ill: F. L. Peacock, 1973.

COMPUTER ASSISTED TESTING AT
THE EDUCATION RESOURCE CENTER

PAPER PRESENTED TO
ADCIS 1978 ANNUAL CONFERENCE IN DALLAS,TEXAS

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INTRODUCTION

Alternative strategies were investigated by faculty to provide more efficient instruction to increasing numbers of students who were expected to learn more and to retain the knowledge longer. Traditional quiz sessions and hourly examinations did not provide for individualizing student progress nor did they provide for additional study and re-testing that would lead to more learning by more students.

Faculty attempted administration of additional group tests during make-up seminars conducted by teaching assistants. This procedure developed scheduling conflicts for both students and instructors. It also raised the issue of comparability of test items used in different sessions. Security of the item pool disintegrated when corrected tests were returned to subjects for discussion or for other feedback. Generating several printed forms of each test from larger item pools appeared as a promising solution.

Procedures for test generation, scoring and statistical treatment were implemented on the computer. Test items were selected randomly, printed as individual tests and items were replaced in the pool for possible inclusion on other forms of the same test. Thus a subject may or may not see the same item at a subsequent testing session. Items were analyzed statistically and compared for level of difficulty. Face validity was approximated by identifying each item with a concept number keyed to a passage in the textbook, supplemental readings, lectures, or laboratory exercises. Proctors could administer and score different tests while the teaching assistants and faculty conducted elective review sessions. This procedure provided subjects with more rapid feedback but created a major clerical burden when used with large classes. It is still used in two courses (Marler, 1975).

Interactive terminal testing was introduced in 1973 to reduce clerical errors and to improve reporting procedures. Utility programs and subroutines were written, debugged and revised as faculty investigated several questions about testing behavior and item construction.

Table 1

UTILIZATION OF COMPUTER ASSISTED TESTING SYSTEM

Year	Number of Hard Copy Tests Generated	Number of Interactive Terminal Tests	Total
1972-73	56	428	484
1973-74	4,891	4,428	9,319
1974-75	6,345	14,107	20,452
1975-76	6,998	11,039	18,037
1976-77	4,435	14,926	19,361

More terminals were added but hard copy tests were retained for backup in case of equipment failure or overload as course deadlines were established (Martuza, 1975). Although progress was limited to a single semester by University regulations, greater flexibility was created for many subjects. During 1977-78 test administration routines were combined into a single computer program and utility programs were grouped in a second package. Prompts and cues in the programs permit the testing staff and faculty to perform tasks formerly reserved for the programmmers and system manager without risking loss of files or records. Programmers devote more time to developing experimental routines to handle additional research question (see Figure 1).

PROCEDURES

At the beginning of each semester, faculty using the CAT System provide test questions with correct responses to the testing staff who create a working file. Draft copies are sent to the faculty for editorial changes or corrections.

Figure 1

CAT SYSTEM PROGRAMS

1. **Testing Program --**

   CATTEST/SUPERVISOR

2. **Utility Programs --**

   SEQ -- SEQUENCER
   UPD -- UPDATEDIR
   PAC -- PACKER
   QDM -- QUESTIONDUMPER (CARDS)
   TGN -- TESTGENER
   ENT -- ENTERNAMES
   ROS -- CLASSROSTER
   MCR -- MCTESTSTUDENTRECORDS
   CRR -- CRTESTSTUDENTRECORDS
   TSC -- TESTSCORES
   SUG -- SUGGESTIONBOX
   NEWS --
   MCB -- MCTESTRECORDSBATCH
   TSB -- TESTSCORESBATCH
   MCT -- MCTEST TOTALANALYSIS
   CRT -- CRTEST TOTALANALYSIS
   HTR -- HISTORYTRACE
   HRE -- HISTORYRELINK

Figure 2

FORMAT OF QUESTIONS

FOR CONSTRUCTING TEST ITEM POOLS

```
1670000   *035F
1672000   WHICH OF THE FOLLOWING IS/ARE STUDENT PRODUCTS OCCURRING IN A
1674000   NATURAL CONDITION
1676000   A.  EVIDENCE OF DEFACEMENT OF SCHOOL PROPERTY
1678000   B.  AMOUNT OF LITTER ON SCHOOL GROUNDS
1680000   C.  AMOUNT OF USAGE WEAR ON CERTAIN GYM EOUIPMENT AS AN INDEX OF
1682000       PREFERENCE FOR CERTAIN GAMES
1684000   D.  A + B
1686000   E.  B + C
1688000   F.  A + B + C
1690000   G.  NONE OF THE ABOVE
1714000   &10013 ****** END OF ED607 PO *******
```

Seq #167000 Item Number and Correct Response

167200 - 1690000 Item

171400 nnn13 Number of questions to be administered for tests in this unit

The final editions of all items pools are transferred to disk pack for use by subjects. Class lists and identification numbers are entered with testing options assigned to each student.

Figure 3

FORMAT FOR ENTERING CLASS LISTS

```
ENTER THE PROPER ITEMS LEFT JUSTIFIED IN THE FIELDS BORDERED BY '*'.
TO SEE THE GUIDE AGAIN, TYPE $GUIDE.
WHEN YOU HAVE FINISHED, TYPE ?END.

 LAST  NAME   FIRST  SSN COURSE     COURSE      COURSE      COURSE
*----------**-------**--**----*     *----*      *----*      *----*

GUEST        ONE      1111PY301Q
GUEST        TWO      2222ED660Q
```

Four testing conditions for terminal tests have been developed to specify how the supervising program is to display questions, record student responses and display the test session summary after each trial. Four selection options specify how test items are selected from the pool. These options are summarized in Figure 4.

Proctors generate hardcopy tests on either the line printer of the Remote Job Entry (RJE) station in the Education Resource Center or on the Xerox printer at the Computing Center. Each test is labeled by course, unit and sequential number (see Figure 5). The answer strips are separated and tests are filed for future use in a standard cabinet within the testing room. Students write their responses in a separate answer sheet and return their tests and answer sheets to the proctor for correcting (see Figure 6).

Student Record files are updated each day to include any hardcopy tests and are printed at the RJE as insurance that computer problems do not result in lost files. These are kept in a chronological file for future reference by faculty or staff. A sample Student Record file is shown in Figure 7 with Student Comments for faculty members to use in revising items or evaluating the System performance.

Figure 4

TESTING CONDITIONS FOR TERMINAL TESTS

Reinforcement Conditions	OPTIONS			
	Complete		70%	
	WR	R	WR	R
"NORMAL": informs the subject if his answer was correct or incorrect. It forces subjects to respond until the correct answer is obtained. Test score is calculated as number correct on first attempt and is displayed at end of trial.	N	R	A	E
"EXAM": the test is given straight through with only one response to each question. Subjects may not go back and change answers. Scores are displayed at the end of the trial.	O	S	B	F
"POST-TEST REVIEW": the subject may go back to review and change answers after all questions have been given. Score is based on final choice and is displayed at end of trial. The subject may elect to review items to learn correct response after score is displayed.	P	T	C	G
"QUICK REVIEW": the subject may go back at any point in the test to review questions and to change answers. Score is based on final choice and is displayed at the end of the trial. Subject may elect to review items to learn the correct response after score is displayed.	Q	U	D	H

The R, or replacement, option permits the same question to be given in another trial. The WR, or without replacement, option assures that none of the questions will be repeated in any subsequent trials by an individual student. The Complete Selection option generates items for subjects on each trial. The 70% option generates items, but terminates subjects at any time when they miss too many items to permit scoring 70% on a test.

Figure 5

SAMPLE HARD COPY TEST

```
                         ED461/ED660 PRETEST  FALL 1977

                    NAME_____________________________        SECTION_____      TIME/TRIAL_____

ED660  NO.= 10      ED660          UNIT=    1                 TEST NO.= 10
UNIT=    1
  ANSWERS

1                      1. THE STATEMENT "JOHNNY IS A BETTER STUDENT THAN MARK" IS
                          ESSENTIALLY -----.
                          A.  CRITERION-REFERENCED
                          B.  NORM-REFERENCED
   ( 14,B)

2                      2. IF THE HEIGHTS OF 10 INDIVIDUALS WERE MEASURED TO THE NEAREST INCH
                          AND EACH PERSON'S HEIGHT SCORE WERE REDUCED BY 5 INCHES, THE
                          RESULTING SCORES WOULD BEST BE CLASSIFIED AS ----- LEVEL
                          MEASUREMENTS.
                          A.  NOMINAL
                          B.  ORDINAL
                          C.  INTERVAL
                          D.  RATIO
   (  8,C)
```

Figure 6

SAMPLE ANSWER SHEET

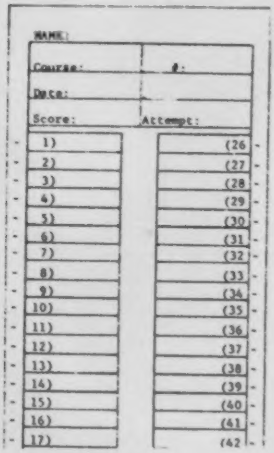

NAME:
Course:
#:
Date:
Score:
Attempt:
1)
2)
3)
4)
5)
6)
7)
8)
9)
10)
11)
12)
13)
14)
15)
16)
17)
(26
(27
(28
(29
(30
(31
(32
(33
(34
(35
(36
(37
(38
(39
(40
(41
(42

Figure 7

SAMPLE STUDENT RECORD

```
NAME:  GUEST, ONE                     IDENTIFICATION:  1111
COURSE: FW211  TEST: 01   TRIAL: 1   UNIT NUMBER: 00
TEST DATE: 09/28/77   TIME ON: 16:41:25    TIME OFF: 12:05:13
RECOVERED

QUESTION     ITEM      CORRECT
 NUMBER     NUMBER     RESPONSE      RESPONSES       CORRECT   TRIES      LATENCY
   01         027         D           E                 N        01        00:16
   02         015         B           E                 N        01        00:16
   03         013         C           C                 Y        01        00:13
   04         028         E           E                 Y        01        00:07
   05         005         D           A                 N        01        00:15
   06         004         A           A                 Y        01        00:10
   07         026         A           A                 Y        01        00:43
   08         006         A           A                 Y        01        00:08
   09         014         D           B                 N        01        00:14
   10         003         B           B                 Y        01        00:17
COMMENT:THIS WAS A GOOD INTRODUCTION  TO COMPUTER TESTING

001 FILES FOUND
```

Complete Score files are printed alphabetically by course at the RJE on a weekly schedule for use by students or faculty. Individual subjects and class lists are available on the printer or terminals at any time if needed for checking accuracy of the records or for monitoring student progress. A sample Student Scores file is shown in Figure 8.

Figure 8

SAMPLE STUDENT SCORES FILE

```
              STUDENT: KOWAL  , ART          ID NUM: 99
     TEST          U2  U1  U3
         TRIAL
            01    07  08  08
            02        11
            03        11
            04
            05
            06
            07
            08
            09
            10
```

Anonymous student suggestions can be printed on demand to provide feedback to the faculty and staff.

Figure 9

SAMPLE ANONYMOUS STUDENT SUGGESTIONS

```
●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
10/03/77                                    12:46 PM.
UNIT: 02
023,009,016,003,002,026,010,008,022,015,
ON TEST NUMBER 2, #3, THE QUESTION WAS ON THE COMBINATION OF 2 FOODS, AN
THEY WANTED TO KNOW WHICH HAD THE BEST COMBINATION OF TASTE AND TEXTURE.
I FEEL THIS QUESTION IS UNFAIR, BECAUSE ONE OF THE CHIOCES MAY BE SOME-
THING I'VE EATEN ALL MY LIFE AND ENJOYED TOGETHER.
●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
10/07/77                                    12:59 PM.
UNIT: 01
005,020,016,017,024,014,013,026,025,023,
IN REGARDS TO QUESTION 5- THE CHOICES WERE NOT CLEAR. 4 1/2 TSP COULD ME
●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
```

Two item analyses are provided to faculty. The partial (see Figure 10) includes data summarizing correctness of responses. At the end of each semester, a complete item analyses include latency response data, subjects' final choices, and the number of times each item was used for interactive testing as shown in Figure 11.

Figure 10

SAMPLE ITEM ANALYSIS REPORT

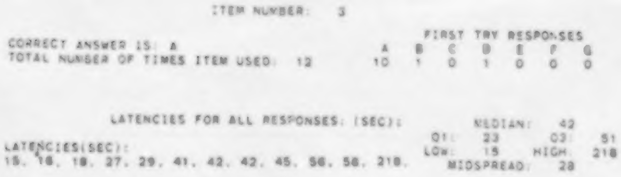
```
                    ITEM/ANALYSIS   10/31/77

              COURSE:  ED660  TEST:  2  UNIT:  00

ITEM  CORRECT       RESPONSE FREQUENCY        TOTAL   CORRECT
      RESPONSE    A   B   C   D   E   F               FIRST TRY
   1     B        0   2   0   0   0   0         2        2
   2     C        1   1   4   0   0   0         6        6
   3     A        1   0   0   0   0   0         1        1
   4     C        0   0   2   0   0   0         2        2
   5     C        0   1   1   0   0   0         2        2
```

Figure 11

SAMPLE COMPLETE ITEM ANALYSIS REPORT



```
                          ITEM NUMBER:   3
                                                          FIRST TRY RESPONSES
CORRECT ANSWER IS: A                                 A    B    C    D    E    F    G
TOTAL NUMBER OF TIMES ITEM USED:  12                10    1    0    1    0    0    0


              LATENCIES FOR ALL RESPONSES: (SEC):                MEDIAN:   42
                                                            Q1:   23        Q3:   51
LATENCIES(SEC):                                            LOW:   15      HIGH:  218
15, 16, 18, 27, 29, 41, 42, 42, 45, 56, 58, 218,             MIDSPREAD:   28
```

Daily procedures for, proctors include setting up the sign-in book, reviewing instructions from the testing coordinator and programmers, and connecting terminals to the Burroughs B7700. Currently, three different models of Beehive cathode ray tube (CRT) terminals are used. The program permits use of DECwriter Model 36A printing terminals, but none are used at this time. Passwords are changed daily for security purposes and to discourage inquisitive students who may have observed the sign-in procedure during a recovery sequence while they were testing.

Each student is provided a Student User Manual at the beginning of the semester. However, some need assistance at their first session. They are assigned to a terminal after the sign-in at the proctor desk for each session. The terminal display provides cues to assist in the log-on process and to prompt students to read any news items concerning their course. A help session is available at the terminal to provide additional instructions for the testing procedures. Students then proceed with their test and respond to each item at the terminal. Proctors refer students to teaching assistants if asked any substantive questions. Some instructors maintain office hours in a consulting room in the Center. Others prefer to advise students in their own offices. This consulting is an important feature of the System.

A PROCTOR'S MANUAL and a SYSTEMS MANUAL provide staff with off-line documentation for the CAT System. Both the supervisor and utility programs provide cues and prompts to assist authorized users with managing the system and producing reports.

RESULTS

Equipment and space allocations indicate that each terminal will provide approximately two tests per hour at the beginning of each semester. The number increases by about fifty percent at the end of any semester. Subjects report that they become more relaxed at the terminals and with the system. During 1974, only two-thirds of the subjects reacted favorably to the interactive testing. During 1976, favorable reaction approached ninety percent. Most negative comments result from equipment failure and wording of test items. Time for hardcopy testing remained stable at about twenty-five minutes per test session. Waiting time for proctors to score tests varied because of the backlog created during peak periods. In addition, time was needed by the testing supervisor to enter test scores.

Subjects were assigned varying reinforcement one semester. However, the experimental treatment had to be terminated because subjects objected that their unequal treatment would cause unjust comparison at grading time.

Grades for final examinations in one course showed greater improvement than did grades in the same course taught during the preceding semester in a traditional lecture and hourly examination mode. Faculty reported fewer gripe sessions with students, feel they have more time for preparing instructional materials, consult with students, and conduct their own research when they use computer assisted testing.

REFERENCES

1. Marler, Charles D., INSTRUCTOR'S GUIDE TO ACCOMPANY PHILOSOPHY AND SCHOOLING, Allyn and Bacon, Boston, 1975

2. Martuza, Victor R., APPLYING NORM-REFERENCED AND CRITERION-REFERENCED MEASUREMENTS IN EDUCATION, Allyn and Bacon, Boston, 1977

DEVELOPMENT OF A PLATO-BASED CURRICULUM FOR TACTILE SPEECH RECOGNITION

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Instructional Systems
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DEVELOPMENT OF A PLATO-BASED CURRICULUM FOR TACTILE SPEECH RECOGNITION

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Abstract

This project has initiated the development of a PLATO-based curriculum, teaching profoundly deaf children to understand speech sounds which are presented as touch patterns on the abdomen. In a unique and innovative process, PLATO's auditory disk output is used to "speak" words and phrases, which in turn are converted to touch patterns via a new sensory aid, the teletactor. This aid presents sound information as flowing, dynamic patterns on the skin, which are learned like,a new language. PLATO, presenting words and phrases via the teletactor, accepts and judges the student's responses in interactive practice and testing. The curriculum utilizes PLATO (a) as a computer-assisted language learning system; (b) as a multimedia interactive communication system; and (c) as a computer management system for psycholinguistic experimentation, evaluation, and statistical analysis.

A tactile sensory aid for profoundly deaf children

The teletactor is designed for children who are too deaf to benefit from conventional hearing aids. Speech and environmental sounds are analyzed according to frequency and are displayed on a belt of tactile stimulators, worn around the abdomen. Each stimulator is sensitive to a specific frequency, and its output represents the amount of energy present within its specific bandwidth. The frequency bands are displayed linearly, from low to high; a "siren" produces a sensation which moves back and forth across the belt.

The formant resonances which characterize different vowel sounds are perceived as a characteristic pattern of two or three simultaneous sensations. Diphthongs combine these patterns in a moving sequence.

Unvoiced stop consonants (/p/, /t/, /k/) are perceived as a brief burst of energy at a single place on the belt, whose position is dependent upon the place of articulation. Voiced stops (/b/, /d/, /g/) provide, in addition, a sensation in the frequency range of vocal cord activity. Fricative consonants such as /s/ and /sh/ are perceived as longer in duration and broader in bandwidth than the stop consonants, and the presence or absence of voicing may be similarly distinguished.

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The sensory aid provides information both about the frequency content of the signal and also about the time-varying envelope properties known as prosodic or suprasegmental features. These features include durational (rhythmic) patterns, intensity stress patterns, and changes in inflection.

A wearable, twenty-channel prototype of the teletactor is shown in Figures 1 and 2, with a total weight of 28 ounces. Figure 3 shows a 32-channel laboratory version of the aid, designed to complement the PLATO terminal. The frequency response of this aid covers the range of normal hearing, from 30 to 16000 Hz, with a frequency discrimination threshold of 1/12 octave. The aid displays sound intensities from 48 db (C-weighted), equivalent to a moderate whisper at 6 feet, to 94 db, with an intensity discrimination threshold of 3 db. The addition of limited automatic gain control provides a further extension of the range.

Speech discriminability via the teletactor display

Previously reported experiments have indicated that untrained subjects can learn to discriminate the basic phonemic features of the English language via the tactile display alone, eliminating all acoustic and lipreading cues, within ten hours of training. Vocabularies of common words, consisting of a few dozen items presented in isolation, can be learned in a comparable period of time. With further training, words learned in isolation can be discriminated when presented within sentence frames, in connected discourse.

Learning a new tactile language

It is clear, however, that the task of learning and discriminating individual words is radically different from the fluent comprehension of ongoing speech. The discrimination of syllables and phonemic features is only a beginning; the learner must also develop the ability to utilize more complex, partially redundant cues such as the prosodic, syntactic, and semantic structure of each utterance. In other words, the process is equivalent to the learning of a new language. For this reason, young children are the most appropriate candidates for this type of training, since they are still within their primary language acquisition age.

PLATO as a language-training system

The success of PLATO in language-training paradigms is well documented. Its rich visual displays, including text, graphics, animation, and full-color slides, are ideal for holding a young child's interest; the touch-sensitive display eliminates the need for typed responses; and the random access audio unit, accessing pre-recorded messages within 1/3 second, is especially well suited for the presentation of language material. Since message duration can vary from 1/3 sec to 45 sec, syllables and sentences can be presented with equal ease.

Psycholinguistic experimentation

An important part of our project activity includes experiments testing the discriminability of specific linguistic features. These experiments have a three-fold purpose. First, we need to ascertain that the teletactor can in fact transform the specific acoustic cue into a tactile pattern suitable for discrimination. Second, we need to be able to estimate the amount of time, and the number of trials, which are required for a subject to reach a specified criterion of accuracy in making the discrimination; these data, by extrapolation, allow us to predict the time required for deaf children to learn the fundamental phonetic distinctions underlying speech. Third, we are able to rank these phonetic features according to difficulty of discrimination. This ordering, based on empirical results, is of prime importance in designing a curriculum, so that the child is presented with material which is graded according to difficulty, and which is appropriate to his achievement level.

These experiments tend to be repetitive, highly structured tasks requiring considerable attention and concentration. We have employed adult, hearing volunteers in these psycholinguistic experiments, for two reasons; first, their periods of intense concentration are longer than those of young children; second, these fairly exhaustive tests are not appropriate for young deaf children in the early stages of tactile speech learning, and might in fact interfere with their more fundamental tasks of vocabulary development, sentence comprehension, and recognition of connected discourse.

By sending the audio disk output directly to the teletactor, we are able to simulate deafness in these experiments, since no audible cue of any kind is available, either from the disk or from the electrotactile display.

These psycholinguistic experiments follow a predictable and standardized format, in which individual stimuli are presented in random order from a set of -n- possible alternatives; a forced-choice response is then collected, and appropriate feedback is given. The set of alternatives can be easily and rapidly changed, by inserting different disks or selecting different disk addresses.

Our current format permits from two to ten alternatives. We can therefore have available a catalog of experiments, such as the discrimination of digits from zero through nine, or the identification of nine vowel placements, and so on. In all of these experiments, a powerful response feedback paradigm is employed: first, the subject is immediately shown whether his response was right or wrong; second, if wrong, the correct response is identified; and third, his cumulative responses are displayed in a matrix. In this way, the subject constantly receives information as to which stimuli he is likely to confuse. An optional help sequence is also available, in which the subject can select and repeat one of the stimuli, attend to its specific pattern, and compare it with other stimuli.

Figure 4 illustrates the type of display encountered by a subject in a digit discrimination task. This experiment is now complete, and is being prepared for publication. Six previously untrained subjects were given blocks of 100 trials each (with an average time of 20 minutes per block). All performed well above the chance of level of 10% after the first block of trials, and achieved a criterion of 90+% accuracy after one to four hours of training.

The curriculum for profoundly deaf children

We have completed a series of lessons which teach, through paired associate learning, a vocabulary of words to profoundly deaf children. Figure 5 shows the graphic drawing of an everyday object. The audio unit plays the name of the object; the sound pattern of the name is then displayed as a touch pattern on the child's abdomen.

After initial presentation and practice, the child is introduced to a two-alternative forced-choice testing paradigm. Two pictures are shown, as in Figure 6, and the name of one object is presented as a touch pattern. The child must respond by touching the display; a correct response is rewarded, while hints and other instructional pointers are given for incorrect responses.

In a series of subsequent lessons, these individual words are presented in sentences of increasing complexity, providing experience in the understanding of connected discourse. Conversational, interactive formats are also possible, stressing the communicative aspects of language. Figure 7 illustrates the discrimination of words within sentence frames; Figure 8 shows a further expansion into idiomatic sentences and phrases, appropriate to "Basic English" or "English as a Second Language".

Preliminary testing of these materials in the laboratory.

We have conducted limited pilot testing of these lessons in our laboratory, with two five-year-old and two thirteen-year-old children. Motivational levels are high, with concentration spans up to forty five minutes for the younger children. Preliminary indications of learning rate are also encouraging; response accuracies of 80% and above are achieved after approximately one hour of training with an eight-word vocabulary; the transfer from individual words to sentence format is equally rapid.

Field-testing in classrooms for the deaf

We are preparing to evaluate this approach to tactile speech perception in collaboration with a special education program for the hearing impaired, operated by the State of California public school system. We plan to utilize a new, extremely lightweight (16 oz) version of the teletactor, along with a portable television-based PLATO system. The results of these tests, in an actual classroom, should be highly informative.

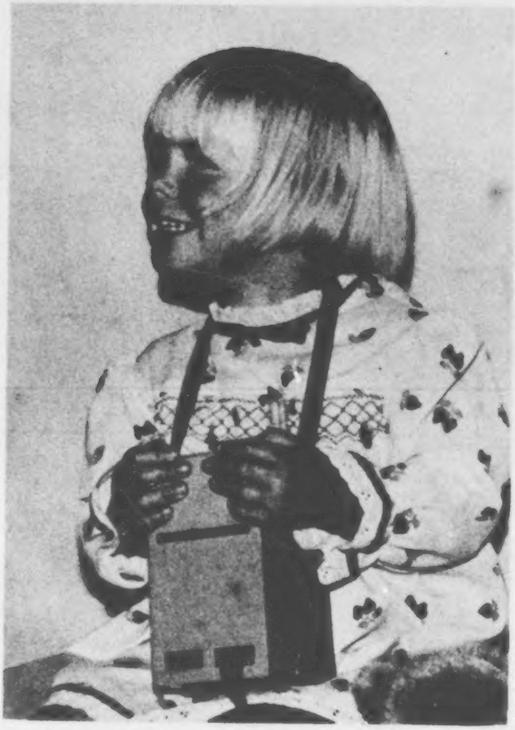

FIGURE 1

A wearable electrotactile sensory aid for the profoundly deaf. The aid analyzes and displays speech sounds according to frequency via a linear tactile array. Weight with rechargeable batteries = 28 oz.; dimensions = 6 x 3 x 4 inches.

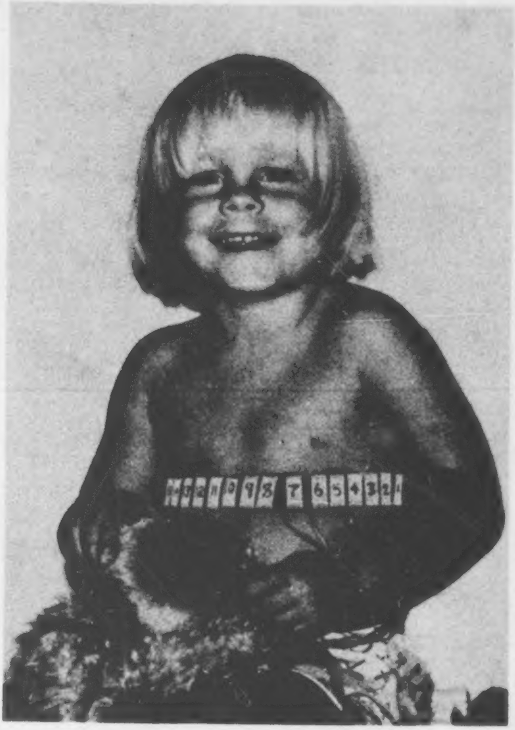

FIGURE 2

Sounds are displayed as dynamic tactile patterns on a belt of electrocutaneous stimulators. Low frequencies (from 31 Hz) are displayed on one end, high frequencies (to 16000 Hz) on the other. The dynamic range for white noise is from 48 db to 94 db (C-weighted).

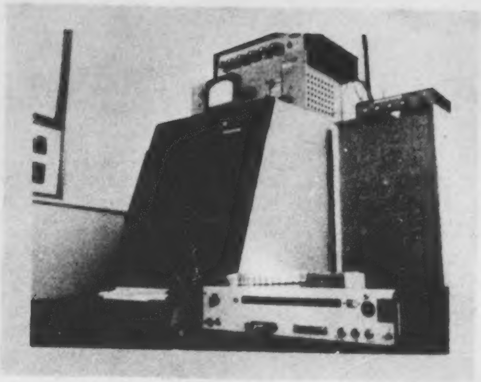

FIGURE 3

A laboratory version of the sensory aid, designed to complement the PLATO system, is shown in the lower right. The tactile belt, with its row of electrocutaneous stimulators, is worn around the abdomen; the tactile patterns corresponding to spoken words are associated with pictures of common objects, as presented on the touch-sensitive visual display.

LIST OF CAPTIONS

Figure 1. A wearable electrotactile sensory aid for the profoundly deaf. The aid analyzes and displays speech sounds according to frequency via a linear tactile array. Weight with rechargeable batteries = 28 oz.; dimensions = 6x3x4 inches.

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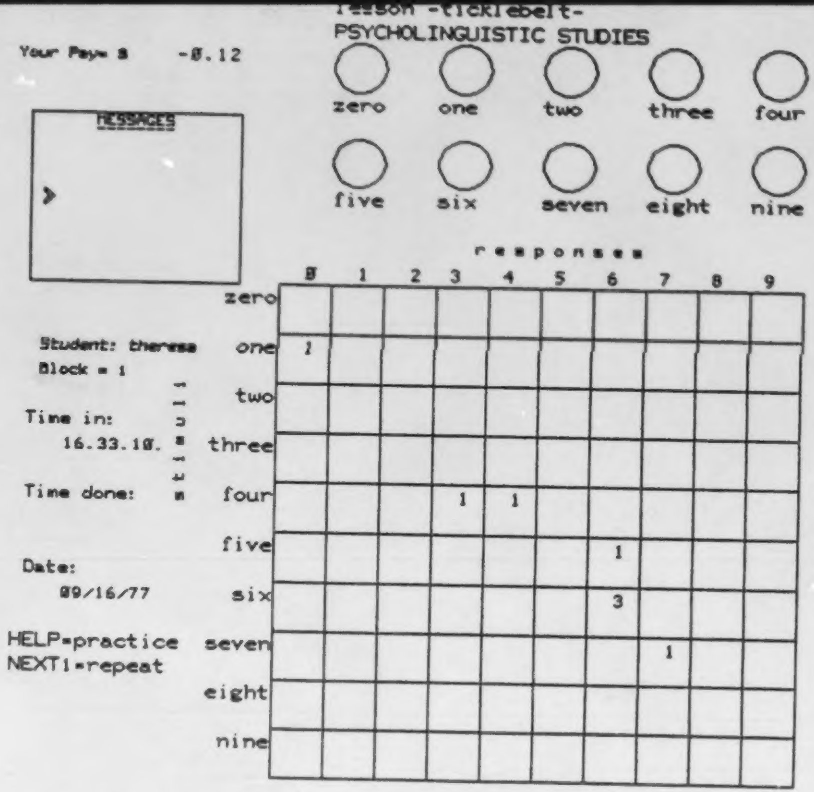
Figure 4. Display format for a 10-alternative discrimination task. Response "buttons" are above; the confusion matrix of responses vs. stimuli is below.

Figure 5. Graphic drawings of everyday objects are paired with spoken words from the random access audio unit. The auditory signal is transformed by the sensory aid into a touch pattern on the skin. The child may repeat the word, by pressing the square.

Figure 6. A two-alternative discrimination task. The child feels the tactile pattern corresponding to one of the two words, and must touch the correct picture.

Figure 7. In this task, previously learned words are embedded in phrases.

Figure 8. Basic English vocabulary words, presented within complete sentences.



lesson -ticklebelt-
PSYCHOLINGUISTIC STUDIES

Your Pay= $ -0.12

MESSAGES

>

○ zero ○ one ○ two ○ three ○ four

○ five ○ six ○ seven ○ eight ○ nine

Student: theresa
Block = 1

Time in:
16.33.10.

Time done:

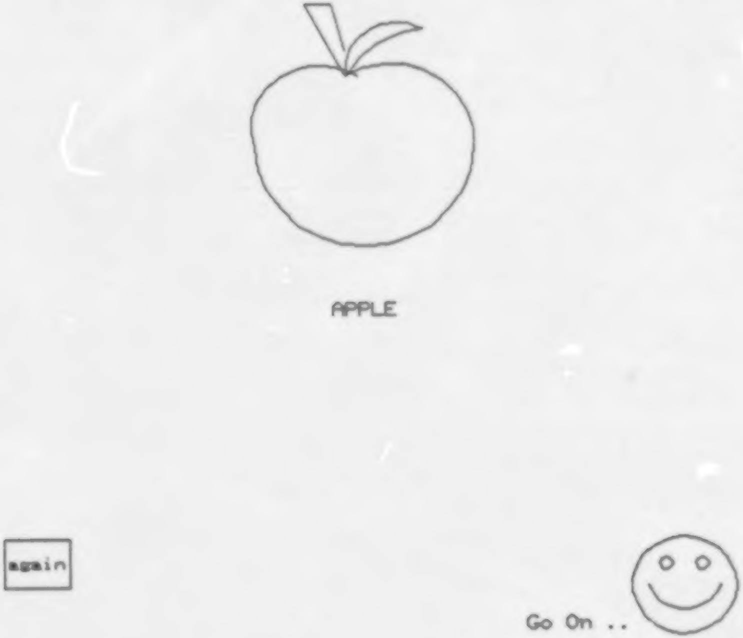
Date:
09/16/77

HELP=practice
NEXT1=repeat

responses

stimuli	0	1	2	3	4	5	6	7	8	9
zero										
one	1									
two										
three										
four				1	1					
five							1			
six							3			
seven								1		
eight										
nine										

Figure 4. Display format for a 10-alternative discrimination task. Response "buttons" are above; the confusion matrix of responses vs. stimuli is below.



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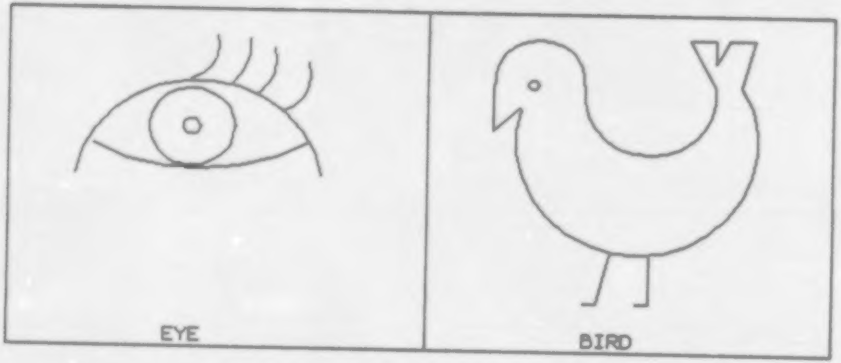
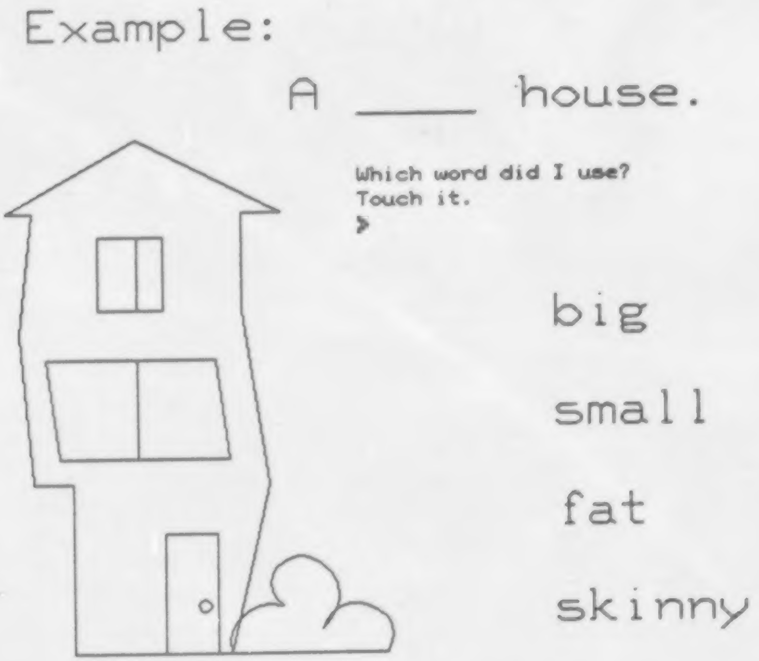


Which one do you feel?

▶

Figure 6. A two-alternative discrimination task. The child feels the tactile pattern corresponding to one of the two words, and must touch the correct picture.



Example:

A ____ house.

Which word did I use?
Touch it.
>

big

small

fat

skinny

Figure 7. In this task, previously learned words are embedded in phrases.

1. This is Me!
2. You are there.
3. I am sitting down.
4. We are going for a walk.

Which of these statements
did you feel?

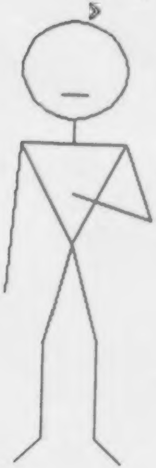


Figure 8. Basic English vocabulary words, presented within complete sentences.

TICCIT+10: A STATUS REPORT

Leonard M. Goldberg
Coordinator of the Department of
Learning Resources

Frank S. Rubin
Marketing/Dissemination Specialist

The Model Secondary School for the Deaf
Gallaudet College

TICCIT+10: A STATUS REPORT

INTRODUCTION

The purpose of this paper is to provide the reader with a current status report of the operational capability and use of the Time shared, Interactive, Computer Controlled, Information Television (TICCIT)+10 computer system at the Model Secondary School for the Deaf (MSSD), Gallaudet College, Washington, D.C.

The TICCIT+10 is a modified version of the TICCIT system, developed by the MITRE Corporation. To make the system more usable by the MSSD, certain features were added to TICCIT's standard components; the resulting system was then linked to a larger computer (DEC-10) on the Gallaudet campus, hence the name TICCIT+10. (Readers are referred to the Bibliography on page 10 for more detailed information about TICCIT or TICCIT+10.)

MISSION STATEMENT AND OBJECTIVES

In planning for work to be accomplished during the initial implementation stages of the TICCIT +10 system, several areas of need were identified as follows:

...Computer Courseware had to be developed and/or purchased which considered the special educational needs of the MSSD's student population.

...Computer programming support had to be provided to various departments within the MSSD to help them achieve their administrative and research goals.

...Resources had to be allocated to maintain and operate the vast array of computer equipment for which the Computer Unit was responsible.

...In-service activities had to be planned and implemented for both Computer Unit personnel and for other MSSD faculty/staff members.

> ...A system had to be formulated and implemented which would provide the users of the TICCIT+10 with continuous support and assistance on a daily basis.

To achieve this mission, objectives were established for the TICCIT+10 Computer Unit:

1. To assist in the development and design of courseware for computer-assisted/computer-managed instruction.
2. To provide computer programming support for instructional, administrative, and research use of the computer.
3. To operate the MSSD computer system, including peripheral and external equipment.
4. To acquire and store shelf-ready computer-assisted instruction programs for student use.
5. To provide in-service and professional enrichment activities for Computer Unit staff.
6. To provide in-service programs on uses of the computer for MSSD faculty/staff in cooperation with the Office of In-Service Planning.
7. To monitor MSSD faculty/staff and students in their use of computer software and courseware.

STAFFING

To meet the objectives as listed, the Computer Unit has been allocated 6.72 FTE personnel. Providing administrative and supervisory guidance is the Coordinator of the Department of Learning Resources (.15 FTE) and the Supervisor of Computer Services (.80 FTE). The Coordinator has eleven (11) years experience in providing educational technology services to deaf and hearing impaired students. The Supervisor of Computer Services has been involved with providing TICCIT services for approximately five (5) years, both at MSSD and at one of the original TICCIT demonstration sites, Brigham Young University (BYU). They are assisted by a secretary (.10 FTE) who provides clerical support.

Assigned to assist the administrators of the Computer Unit is a staff of computer programmers, computer operators and technical support personnel. This staff brings a combined experience of approximately forty-five (45) years of working with computer technology:

Senior Programmers	2.00 FTE
Computer Operators	2.00 FTE
Technical Manager/System Engineer	.12 FTE
Systems Electronic Technician	.80 FTE

Providing software development support to the Computer Unit is a staff of diverse personnel from the other units of the Department of Learning Resources:

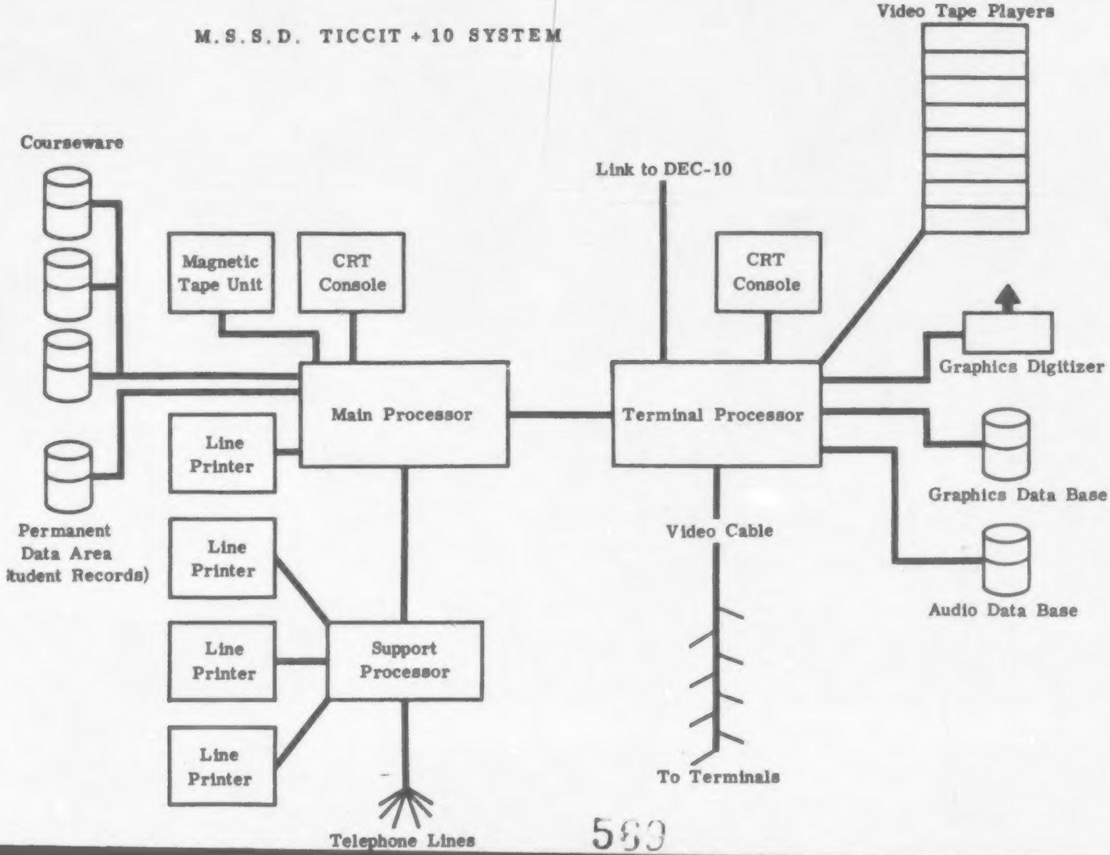
Assistant for TV Production/Direction	.15 FTE
TV Scriptwriter/Packager	.25 FTE
TV Production Specialist	.05 FTE
Editor/Caption Writer	.05 FTE
Transcriber/Production Assistant	.05 FTE
Materials' Evaluator	.10 FTE
Acquisitions Associate	.10 FTE

Also involved in the production of software for the TICCIT+10 system are teams of content specialists, instructional design specialists, evaluation specialists, photographers, and artists.

SYSTEM'S CONFIGURATION STATUS

There are eighty-three (83) TICCIT+10 terminals in operation at the Model Secondary School for the Deaf, including sites at student dormitories and at strategic locations on Gallaudet College campus. The system is operating at full capacity and response time for a user is under one-half (1/2) second.

M.S.S.D. TICCIT + 10 SYSTEM


Video Tape Players
Courseware
Link to DEC-10
Magnetic Tape Unit
CRT Console
CRT Console
Graphics Digitizer
Main Processor
Terminal Processor
Line Printer
Graphics Data Base
Permanent Data Area tudent Records)
Video Cable
Line Printer
Audio Data Base
Line Printer
Support Processor
Line Printer
To Terminals
Telephone Lines

At this time, all the system's functions are operational and being utilized by students and staff:

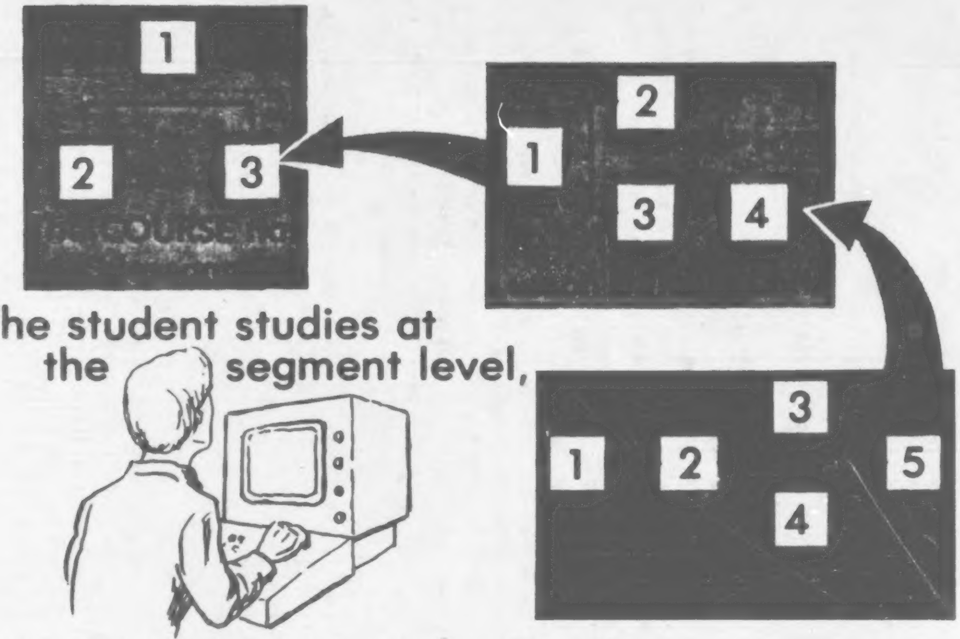
- .The GRAPHIC DIGITIZER enters artwork semi-automatically into the computer.
- .The AUDIO system aids hearing impaired students with some residual hearing.
- .The STUDENT RECORD KEEPING feature monitors student progress with CAI/CMI programs.
- .The MAILBOX feature allows messages to be left on the computer system for one or more other system users.
- .TERMINAL-TO-TERMINAL COMMUNICATION allows a user to converse with another user also logged onto the system.
- .The TTY (Teletypwriter) capability allows the TICCIT+10 terminal to function as a TTY displaying on-screen communication and generating paper copy through a remote line printer.
- .The VIDEOPHONE enhances two-way communication for the hearing impaired by allowing the transmission of both aural and visual signals between one to twenty-five users.
- .The CABLE TELEVISION system is linked to the TICCIT+10 and provides live and video-taped programs.

Being added to the TICCIT+10 system is a third Data General NOVA 830. This mini computer will be used for data reduction activities and as a back-up system. Simultaneous use of both administrative and instructional processes will be possible with this addition to the system's configuration.

SOFTWARE STATUS

Currently, instructional design teams are working on the development of the first two (2) TICCIT+10 courses expressly designed for MSSD's special student population. The first course, "Orientation to Communication," is undergoing developmental evaluation and the second course, "Introduction to Art," is in the planning stage.

COURSE ORGANIZATION


1
2
3
1
2
3
4
3
1
2
5
4

The student studies at the segment level,

one concept or one rule at a time.

Available for instructional purposes are two (2) TICCIT courses developed by Brigham Young University in the areas of mathematics and English and nineteen (19) video-tapes supporting these subject areas. Additionally, this VIDEO-TAPE LIBRARY contains one-hundred-twenty-five (125) captioned videotapes and it is managed by the computer's random access/retrieval system through eight (8) video cassette tape decks.

Also available for students and faculty are a collection of computer games which are designed for either instructional or entertainment purposes, and numerous computer programs which deal with personnel, student, budget, research or operational information, stored within the DEC-10. The capability exists for users to create their own computer programs using a variety of computer languages.

DISSEMINATION STATUS

The Model Secondary School for the Deaf plans to share with professionals in the field of education of the deaf and other interested individuals modified versions of TICCIT+10 courseware and related supplemental materials. There will be considerable effort expended to research the instructional variables inherent in the education of hearing impaired students and the role TICCIT+10 can play in that teaching/learning effort; these results will be shared nationwide as well.

Currently, MSSD's dissemination effort concerning TICCIT +10 is limited to a small collection of papers and presentations, which deal with an overview of the computer system, its uses, and its potential impact on the education of the deaf.

INFORMATION

For more information about TICCIT+10, please contact:

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The Model Secondary School for the Deaf
Kendall Green
Washington, D.C. 20002

SELECTED BIBLIOGRAPHY

Courseware, Inc. Overview of TICCIT Authoring. San Diego, Calif.: Courseware, 1976.

Elliott, P.H. and Watson, P.G. A Research Agenda for the Model Secondary School for the Deaf TICCIT System. Washington, D.C.: MSSD, 1976.

Goldberg, L.M. and Rubin, F.S. An Overview of the TICCIT+10 Computer System at the Model Secondary School for the Deaf. Paper presented at CAID Convention, Los Angeles, Calif., June 1977.

Hazeltine Corporation. Welcome to Time-shared Interactive Computer Controlled Information Television. McLean, Va.: Hazeltine Corporation.

Jones, M.C. TICCIT Courseware Delivery System. McLean, Va.: Hazeltine Corporation, 1976a.

Jones, M.C. TICCIT Mailbox Communication. McLean, Va.: Hazeltine Corporation, 1976b.

Mitre Corporation. An Overview of the TICCIT Program. Washington, D.C.: The Mitre Corporation, 1976.

Morton, R.P. Design of the MSSD Interactive Television System. Working Paper #10981, Washington, D.C.: The Mitre Corporation.

Rappaport, W. and Olenbush, E. Tailor-made Teaching Through TICCIT. Bedford, Mass.: The Mitre Corporation, 1975.

Watson, P.G. The TICCIT System for the New Model Secondary School for the Deaf. Paper presented at ADCIS Convention, Portland, Maine, August 1975.

AUDITORILY AUGMENTED INTERACTIVE THREE-DIMENSIONAL TELEVISION AS AN AID TO LANGUAGE LEARNING AMONG DEAF AND HEARING IMPAIRED CHILDREN

Margaret S. Withrow, Ph.D.
Project Director

A major requirement for success in the American school system is the ability to understand and use language in all of its various expressive and receptive forms. Deaf children, through an inability ot hear the spoken language, generally have reduced language and reading abilities. Even when sound is amplified to allow optimum use of residual hearing, deaf and hearing impaired children do not receive clear signals of spoken language components. For hearing children, emphasis on language skills in the early educational life of a student seems to have positive and lasting effects upon that student's ability to cope with the routine requirements of learning within school programs. Early and intensive programs designed to develop basic language skills are equally important for deaf and hearing impaired children. The opportunity to develop these skills using the common symbols of the larger society may require different educational techniques.

This project is designing educational materials which coordinate spoken and written language so that they interact synergistically. The combination of television and the new technique of three-dimensional computer graphics has been selected for this particular project on the basis of the flexibility offered by this medium to accomplish the special effects required to provide new experiences for deaf and hearing impaired children. Such techniques allow the materials designer to control time, space, and audition in a manner which will emphasize specific linguistic principles. This project exploits a unique thrr-dimensional computer animation system developed un National Science Foundation support. It is intended for the production of color videotapes where scenes and objects are displayed on a TV monitor with the visual cues such as perspective, color, light source, etc., to represent a geometric three-dimensional world. The system is aimed at the animator, educator and artist who requires anything from a high volume of short color sequences for teaching purposes, to realistic key frame animation involving complex color objects and precisely time life-like movements. The linguistic principles selected for this project are (1) specified prepositional constructions, and (2) relativization.